LEARNING FROM VARIATION IN OUR STATE DATA

Theresa A Scott, MS
Sr Application Developer, TIPQC
## BRIEF REVIEW

### Why are we here today?

**AIM:** to decrease the rate of growth failure in VLBW infants in Tennessee Neonatal Intensive Care Units.

### How are we going to do this?

Make changes that will result in improvement using the Model for Improvement.

### What does all of it rely on?

Data

---

Image source: edX HarvardX “PH556x Practical Improvement Science in Health Care: A Roadmap for Getting Results”
USING DATA FOR IMPROVEMENT

What is data?
- At its simplest: Data is information.
- More formally: Data are documented observations and measurements.
  - An observation comes from our unique perceptions using our senses.
    - Example: Observe that an infant’s breathing has improved.
  - A measurements is the result of performing a measurement process.
    - Example: Measure the same infant’s heart rate, oxygen saturation, and breaths per minute.

Data in the Model for Improvement:
- Improvement projects are about testing, adapting, implementing, and spreading changes.
- Play important supportive roles:
  - Using key measures to assess progress toward the project’s aim.
  - Using specific measures for learning during PDSA cycles.
  - Using balancing measures to assess whether the system as a whole is being improved.
  - Using data from the system to focus improvement and refine changes.
- Data provides us the feedback we need to know if our changes are resulting in improvement.
  - REMEMBER: All improvement requires change, but not all change results in improvement.

Source: Health Care Data Guide, Ch. 2 (see “REFERENCES”)
DATA AND VARIATION

- There is always variation in data.
  - Examples: the daily temperature; the success of a surgical procedure.

- Variation in data is both normal and constant.
  - You can’t avoid it and it will always be present.

- Variation can complicate our ability to learn from our data.
  - Learning often comes from understanding the themes and patterns in the data.
  - We make decisions based on our interpretation of these patterns – especially regarding improvement efforts.
  - If we do not understand variation in data, we may not make the best decisions.

- Variation (according to Walter Shewhart, the father of Statistical Quality Control) can be viewed in two ways:
  - (1) As an indication that something has changed (a trend); or
  - (2) As random variation that does not mean a change has occurred.

Sources: Improvement Guide, Ch. 2; IHI.org > “Understand Variation in Data” (see “REFERENCES”)
DATA AND VARIATION, CONTINUED

- How do you maximize the learning from your data?
  - Plot your data over time – preferably both before and after a planned change is implemented.

- Plotting data over time
  - Allows the information to unfold as it happens and eventually display a pattern, which will include the variation in your data.
  - Allows you to judge whether the variation is random or forms a pattern that indicates that a meaningful change has occurred.
    - Data that varies randomly exhibits patterns similar to those seen in the past. That is, the values are predictable within certain limits.
      - In this cases, more fundamental changes are needed to bring about true improvement.
    - When a meaningful change has occurred, the variation in the data no longer follows a predictable pattern.
      - The plot may show an isolated observation or two that are outside the predictable range, or show a new trend.

Sources: Improvement Guide, Ch. 2; IHI.org > "Understand Variation in Data" (see “REFERENCES”)
**DATA AND VARIATION: EXAMPLES**

Fig 2.2: Reason why always complained on Sunday night about all the homework that needed to be done was that no studying was done on Fri or Sat.

Fig 2.3: Weight taken every morning for one month; diet started at beginning of week 2. The weights vary, but variation is consistent between 164 to 168. Not yet losing weight, but not gaining it either.

Fig 2.4: While the number of patient beds being used in the hospital varied throughout the 5-year period, it is clear that the average number of beds dropped at about the time an emergency clinic was opened.

Fig 2.5: Data collected by a young man trying to learn to deal with his asthma. On Day 31, obvious reduced lung capacity. Young man started his medication on that day. Allowed him to react quickly to special circumstances.

Sources: Improvement Guide, Ch. 2; IHI.org > “Understand Variation in Data” (see “REFERENCES”)
One of the key strategies in improvement is to control variation.

Two main types to control:
- **Intended variation**: Often called purposeful, planned, guided, or considered variation.
  - Is an important part of effective, patient-centered health care.
  - Example: a physician purposefully prescribes different doses of a drug to a child and an adult.
- **Unintended variation**: Due to changes introduced into health care process that are not purposeful, planned, or guided.
  - The changes can come from decisions made, but usually show up through equipment, supplies, environment, measurement, and management practices.
  - Often, health care professionals are not even aware that the changes are happening as care is delivered.
  - Creates inefficiencies, waste, rework, ineffective care, errors, and injuries.

Walter Shewhart focused his studies on unintended variation.
- Found that reducing unintended variation in a process usually resulted in improved outcomes.

Source: Health Care Data Guide, Ch. 4 (see “REFERENCES” slide)
CAUSES OF VARIATION

A fundamental concept for the study and improvement of processes, due to Shewhart, is that variation in a measure of quality has its origins in one of two types of causes:

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

Causes of variation and a system*:

- **Stable system**: a system that has only common causes affecting its outcomes (i.e., one that is in a state of statistical control).
  - A stable process implies that the variation is predictable within statistically established limits.
  - Does NOT mean that the stable system is performing well (i.e., may be producing very undesirable results).
- **Unstable system**: a system whose outcomes are affected by both common cause and special causes.
  - The magnitude of the variation from one time period to the next is unpredictable.

* System = an interdependent group of items, people, or processes working together toward a common purpose.

- “Every system is perfectly designed to deliver the results it produces” (Central Law of Improvement)
  - Implications: if the system is not producing the quality of products or services needed and wanted by the customer, then the system must be changed in some fundamental way to produce improved results.

Source: Health Care Data Guide, Ch. 4 (see "REFERENCES" slide)
Distinction between the causes of variation is fundamental to developing effective improvement strategies.

**Type of Variation**

- **Reduce unnatural variation (Special Cause)**
  - Learn from and act on special cause(s)

- **Reduce natural variation & improve process (Common Cause)**
  - Change the system

**Type of Improvement Action**

- Establish stable work process
- Improve overall outcomes

Source: Gupta & Kaplan, Hot Topics in Neonatology, 2015 (see "REFERENCES" slide)
SPECIAL CAUSE: IS IT GOOD OR BAD?

- It depends.
  - May be evidence of process degradation or even of an unintended consequence of a change you’re testing.
  - May be evidence of improvement.

- When the special cause produces an *unfavorable result* → remove it and make it difficult for it to occur again.
  - Example: Begin using a new medical device only to find that many patients using it get infections.
  - As unfavorable special causes are identified and removed, the process becomes stable.

- When the special cause produces a *favorable result* → make it a permanent part of the process.
  - Example: A new employee takes a particular x-ray in a different way from the established method. You note their x-ray retake rate is lower than that of the other employees and constitutes favorable special cause. You study their approach and adopt it as the new standard technique for all x-ray technicians.
  - NOTE: In improvement projects, often introducing changes into a stable process, hoping to produce a signal of special cause that indicates an improvement in the process.

- REMEMBER: Special cause needs to be considered in context before determining whether it is good or bad for the system as a whole.

Source: Health Care Data Guide, Ch. 4 (see "REFERENCES" slide)
**DEPICTING VARIATION**

- **REMEMBER**: Effective visual presentation of data (i.e., a good graphic), instead of a tabular display, displays the most opportunity for learning to take place.

- Five fundamental tools to learn from variation in data:
  - 1. Run chart
    - Study variation in data over time; understand the impact of changes.
  - 2. Shewhart chart
    - Distinguish between special and common causes of variation.
  - 3. Frequency plot
    - Understand location, spread, shape, and patterns of data.
  - 4. Pareto chart
    - Focus on areas of improvement with greatest impact.
  - 5. Scatter plot
    - Analyze the associations or relationships between two variables.

Source: Health Care Data Guide, Ch. 4 (see “REFERENCES” slide)
INTRO TO SHEWHART CHARTS

- Often called a “control chart” because of relationship to “Statistical Quality Control”.
  - Misleading in the context of quality improvement.
  - More descriptive name: “learning chart” or “system performance chart”.

- Method of Shewhart charts include:
  - Selection of a measure and a statistic to be plotted.
  - A method of data collection: observation, measurement, and sampling procedures.
  - A strategy for determining subgroups of measurements (including subgroup size and frequency).
  - Selection of the appropriate Shewhart chart.
  - Criteria for identifying a signal of a special cause.

- IMPORTANT: May look like an extension of the run chart, but it actually uses different theory in its construction and interpretation.

Source: Health Care Data Guide, Ch. 4 (see “REFERENCES” slide)
## Run Chart vs Shewhart Chart

<table>
<thead>
<tr>
<th>Run chart</th>
<th>Shewhart chart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What’s the difference?</strong></td>
<td><strong>Which to choose?</strong></td>
</tr>
<tr>
<td>• Data is usually displayed over time.</td>
<td>• Useful when you don’t yet have a great deal of data and you want to rapidly detect signals of improvement.</td>
</tr>
<tr>
<td>• Data is usually displayed in time order.</td>
<td>• Makes the amount of process variation visible, aids in detecting improvement, and helps to determine whether improvement has been maintained.</td>
</tr>
<tr>
<td>• Includes:</td>
<td>• Cannot reliably distinguish special from common cause variation.</td>
</tr>
<tr>
<td>• Data points</td>
<td>• When enough data are available, a Shewhart chart is preferable to a run chart.</td>
</tr>
<tr>
<td>• Median line</td>
<td></td>
</tr>
<tr>
<td><strong>Data is usually displayed over time.</strong></td>
<td><strong>Can aid in distinguishing between special and common cause variation.</strong></td>
</tr>
<tr>
<td><strong>Data is usually displayed in time order.</strong></td>
<td><strong>Enables us to determine process stability, process capability, and to select the appropriate improvement strategy.</strong></td>
</tr>
<tr>
<td><strong>Includes:</strong></td>
<td></td>
</tr>
<tr>
<td>• Data points</td>
<td></td>
</tr>
<tr>
<td>• Center line (usually mean)</td>
<td></td>
</tr>
<tr>
<td>• Upper and lower “control limits”</td>
<td></td>
</tr>
</tbody>
</table>

Source: Health Care Data Guide, Ch. 4 (see “REFERENCES” slide)
SHEWHART CHARTS: PHASES AND USES

UNDERSTAND THE PAST (& CURRENT) PROCESS PERFORMANCE
• Additionally understand its degree of consistency and predictability.

ESTABLISH A STABLE PROCESS
• Iterative process of identifying and removing current existing causes of unnatural (ie, special cause) variation so as to achieve a consistent and predictable level of process quality over time.

IMPROVE THE STABLE PROCESS
• Iterative process of identifying and removing causes of natural (ie, common cause) variation and testing whether interventions result in an improvement.

MONITOR THE PROCESS FOR INSTABILITY
• Monitor for process deterioration and “holding gains” by identifying new special cause of unnatural variation if and when they arise in the future.

Source: Benneyan, 2008 (see "REFERENCES" slide)
KEY POINTS:

- Variation in healthcare care occurs at multiple levels, including geographic, institutional, and individual provider.
- Divergence of practice and lack of standardization are linked to poor outcomes.
- After analyzing the underlying sources of variation in practice, need to identify which types of variation should be encouraged (ie, not all variation is bad) and which should be minimized or eliminated.
- Efforts to improve quality of care should attempt to balance customization and standardization of care – to decrease unwanted variation and still promote favorable variation in practice.

“The challenge in neonatal care lies in the dichotomy between ensuring that neonates in all parts of the world are equally likely to receive the best evidence-based care, while allowing for individualization. The art of practicing medicine lies in navigating these types of decisions, and wisely judging when to standardize based on science or customize based on the patient’s (and family’s) needs and the clinician’s intuition.
### Variation Across Our State

- Number of VLBW infants per month -

<table>
<thead>
<tr>
<th>Center</th>
<th>05/16</th>
<th>06/16</th>
<th>07/16</th>
<th>08/16</th>
<th>09/16</th>
<th>10/16</th>
<th>11/16</th>
<th>12/16</th>
<th>01/17</th>
<th>02/17</th>
<th>03/17</th>
<th>04/17</th>
<th>05/17</th>
<th>06/17</th>
<th>07/17</th>
<th>08/17</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>13</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>11</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>11</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>15</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>19</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>17</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td>18</td>
<td>8</td>
<td>9</td>
<td>13</td>
<td>12</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>12</td>
<td>19</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>15</td>
<td>8</td>
<td>11</td>
<td>19</td>
<td>14</td>
<td>8</td>
<td>0</td>
<td>203</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>15</td>
<td>21</td>
<td>29</td>
<td>17</td>
<td>21</td>
<td>16</td>
<td>18</td>
<td>10</td>
<td>9</td>
<td>22</td>
<td>20</td>
<td>16</td>
<td>23</td>
<td>7</td>
<td>0</td>
<td>261</td>
<td></td>
</tr>
</tbody>
</table>
VARIATION ACROSS OUR STATE
- Characteristics of the VLBW infants at birth -

Percent Male

Historic  ‘Baseline’ Prospective  ‘Active’ Prospective

Percent
VARIATION ACROSS OUR STATE

- Characteristics of the VLBW infants at birth -

EGA (completed weeks)

<table>
<thead>
<tr>
<th>Completed Weeks</th>
<th>Historic</th>
<th>‘Baseline’ Prospective</th>
<th>‘Active’ Prospective</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VARIATION ACROSS OUR STATE
- Characteristics of the VLBW infants at birth -

Birthweight (grams)

<table>
<thead>
<tr>
<th>Grams</th>
<th>Historic</th>
<th>‘Baseline’ Prospective</th>
<th>‘Active’ Prospective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1425</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1325</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1225</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>925</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>825</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>725</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>625</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19
VARIATION ACROSS OUR STATE

- Characteristics of the VLBW infants at birth -

Growth at birth

Historic  ‘Baseline’ Prospective  ‘Active’ Prospective
VARIATION ACROSS OUR STATE

- OUTCOME MEASURES -

(infants with ‘normal growth’ at birth)
VARIATION ACROSS OUR STATE

- OUTCOME MEASURES -

(infants with ‘normal growth’ at birth)

Growth at 36 weeks CA

Percent

0 10 20 30 40 50 60 70 80 90 100

Historic  ‘Baseline’ Prospective  ‘Active’ Prospective
VARIATION ACROSS OUR STATE

- OUTCOME MEASURES -

*(infants with ‘normal growth’ at birth)*

Growth Velocity

<table>
<thead>
<tr>
<th>Historic</th>
<th>‘Baseline’ Prospective</th>
<th>‘Active’ Prospective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Growth velocity (grams/kilo/day)
VARIATION ACROSS OUR STATE

- PROCESS MEASURES -

Hour of life parenteral protein started

‘Baseline’ Prospective
‘Active’ Prospective
VARIATION ACROSS OUR STATE

- PROCESS MEASURES -

Hour of life parenteral lipids started

‘Baseline’ Prospective

‘Active’ Prospective
VARIATION ACROSS OUR STATE

- PROCESS MEASURES -

Days to first feed

'Baseline' Prospective

'Active' Prospective
VARIATION ACROSS OUR STATE

- PROCESS MEASURES -

Days to first achieved 110-130 kCal/kg/day from feeding

Days

‘Baseline’ Prospective

‘Active’ Prospective
VARIATION ACROSS OUR STATE

- PROCESS MEASURES -

Days to regain/return to birthweight

Days: 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1

‘Baseline’ Prospective

‘Active’ Prospective

* Only N = 67 infants *

* Only N = 288 infants *
WHAT DID WE LEARN FROM OUR STATE DATA?

- General take-aways:
  - We had a fairly consistent population of VLBW infants at birth, even though growth at birth has varied over the time of the project.
  - Our process measures have improved.
  - We have not seen marked improvement in our outcome measures.

- Why haven’t our outcome measures improved?
  - Potential data entry errors as well as missing data.
  - Still a fair amount of variation in some of our process measures.
  - Are there other process measures we are not measuring?
  - Are there other aspects of the infants (eg, feeding intolerance) that are affecting our ability to keep specific infants on the feeding protocols and thus resulting in poorer outcomes?

- What about a “deep dive”?
  - Typically, into those infants that do poorly.
  - This time, perhaps focus on those infants who were a “success”.
    - Perhaps those infants with ‘normal growth’ at birth that had a change in weight z-score ≥ 0 → N = 40.
    - What is different about them?
REFERENCES


• The Health Care Data Guide: Learning from Data for Improvement, by Lloyd P Provost, Sandra K Murray

• edX “PH556x: Practical Improvement Science in Healthcare: A Roadmap for Getting Results”
  • Don Goldmann, MD (Harvard & IHI); Dave Williams, PhD (IHI); and Don Berwick, MD, MPP, FRCP (IHI)


• Slides presented by Munish Gupta, MD, MMSc and Heather Kaplan, MD, MSCE for their session titled “Data Management for Quality Improvement: Tool You Should Be Using Now” presented at the 2015 “Hot Topics in Neonatology” conference.

• Websites:
  • IHI.org (Institute for Healthcare Improvement)