Quality Improvement Charts

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Objectives

1. Understand the basic anatomy of charts used in quality improvement (QI): run charts and process control charts.

2. Understand some of the basics to interpreting QI charts.
Outline

- Run charts
- Process control charts
Quality Improvement

- Quality improvement is the combined and unceasing efforts of everyone to make changes that will lead to better patient outcomes (health), better system performance (care), and better professional development (learning).

Batalden PB, Davidoff F. What is “quality improvement” and how can it transform healthcare? *Qual Saf Health Care.* 2007;16(1):2–3
Quality Improvement

- Implementing change to improve processes and outcomes
- Determining if the changes tested resulted in an improvement
- Determining if the improvements are sustained
Before and After Comparisons

Reducing emergency department (ED) oral steroid use in bronchiolitis

![Bar graph showing the reduction in steroid use before and after intervention. The graph indicates a decrease from about 80% before to about 30% after.]
Before and After Comparisons
Reducing ED oral steroid use in bronchiolitis

Week

% Steroid Use

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Before and After Comparisons

Reducing ED oral steroid use in bronchiolitis

Week

% Steroid Use

1 2 3 4 5 6 7 8 9
0 10 20 30 40 50 60 70 80 90 100
Before and After Comparisons

- Aggregate data does not provide information to help us understand whether a change was an improvement.
Run Charts

- Allows for a temporal view versus a static view of data
- Displays data to make process performance visible
- Determines if changes tested resulted in an improvement
- Determines if an improvement is sustained

Run Charts

- Graphical display of data plotted in some type of order
- Horizontal axis is most often a time scale (days, weeks, months, quarters)
- Vertical axis represents the quality indicator being studied (e.g., infection rate, number of patient falls)
- Median is calculated and used as the chart’s center line
  - Provides the point at which half the observations are expected to be above and below the center line
  - Median value is not influenced by extreme values in the data
Example of a run chart demonstrating compliance with a standard procedure

Testing a Change With a Run Chart

Plot baseline

Extend the median and begin the test

Run Charts: Interpreting

- Three probability-based rules for identifying signal change:
  1. Shift
  2. Trend
  3. Run
Run Charts: Interpreting

1. Shift
   - Six or more consecutive points either all above or all below the median values
   - Values on the median do not add or break a shift
   - Skip all values that fall on the median and continue reading
Rule 1: Shift
Run Charts: Interpreting

2. Trend

- Five or more consecutive points all going up or all going down
- If the value of 2 or more consecutive points is the same, only count the first point and ignore the repeating values
- Like values do not make or break a trend
Rule 2: Trend

Run Charts: Interpreting

3. Runs

- A run is a consecutive series of data points above or below the median.

- If only chance is influencing the process then there should be a regularity at which data points go above or below the median.

- A non-random pattern is signaled by too few or too many runs (ie, the median is crossed too few or too many times).

- An easy way to count the number of runs is to count the number of times the data points cross the median and add one; then, look up a statistical table to see an appropriate number of runs to expect.
Rule 3: Number of Runs

Data line crosses once
Too few runs: total 2 runs

Run Charts: Interpreting

- One non-probability-based rule:
  - Astronomical point—used in detecting unusually large or small numbers. This is subjective and recognizes the importance of the visual display of the data in a chart.
Rule 4: Astronomical Data Point

Testing a Change with a Run Chart

Continue to plot data following the change

Apply the rules

If there was a signal, re-plot with new median

First-line Antibiotic Prescribing in the ED
May 2011 – July 2012

Run chart for appropriate first-line antibiotic prescribing for CAP in the ED.

Run Charts: Limitations

- Designed for the early detection of signals of improvement or degradation in a process over time
- Not capable of determining if a process is stable
- Difficult with discrete data (e.g., value is 0 or 100%)
Control Charts

- Like run charts but have more statistical power to detect changes and improvements

- Basic structure
  - Run chart with a line drawn at the average (mean) and pairs of control limits
  - Control limits show 1, 2, or 3 standard deviations (SDs) for the plotted data (usually 3 SDs)
  - Data can be in various forms: percentages, rates, counts, individual values
Control Charts

- Based on the principle of variation
  - Common variation
    - Variation that is to be expected
    - Chance cause
    - When a process is in “statistical control” then it shows only common cause variation
  - Special cause variation
    - Assignable cause
    - Due to something unusual or rare
    - When a process is not in “statistical control” then it shows special cause variation
Control Charts: Interpreting

- Common Rules for Identifying Special Cause Variation
  1. Beyond Limits
  2. Run or Shift
  3. Trend
  4. Sawtooth
  Many more...
Rule 1. Beyond Limits

One or more points above upper (UCL) or below (LCL) control limits

Probability: This outcome is observed only 0.5% of the time (1/200).

Rule 2. Run or Shift

Eight or more consecutive points above or below but on the same side of the center line

Probability: Occurs by chance in 1/256

Rule 3. Trend

Seven or more consecutive points (of 20 or more total points) or 6 or more consecutive points (if total points are fewer than 20), all either ascending or descending

Rule 4. Sawtooth

Fourteen or more consecutive points alternating above and below the center line

Control Charts: Interpreting

- Approach
  - If there is no special cause variation then look at the average.
    - The average tells us whether the process is good.
    - A process can be in control but still be poor.
  - If there is a special cause variation then consider context.
    - Is the special cause something you intended (ie, a change you introduced)?
    - Is the special cause something you did not intend? If so, study the special cause.
Control Charts Types

- **Data type**
  - Variable (continuous)
    - Number of measurements per data point
      - 1: X-mR
      - 2–9: XBar-R
      - >10: XBar-S
  - Attribute (count)
    - Two types of count data (in % or proportion)
      - Defects (count of total number of defects)
        - Chart assumptions
          - Fulfilled
            - Sample sizes vary: U
            - Sample sizes are equal: C
          - Not fulfilled
            - Sample sizes vary: X-mR
            - Sample sizes are equal: P
      - Defectives (count of dichotomous or yes/no events)
        - Chart assumptions
          - Fulfilled
            - Sample sizes vary: NP
            - Sample sizes are equal: X-mR
          - Not fulfilled
            - For rare events: G
Annotated g-chart showing count of osteomyelitis cases between patients with osteomyelitis that were discharged on intravenous antibiotics. Note that median and control UCL were calculated based on preintervention and postintervention cases between data.

Abbreviations: IV, intravenous; UCL, upper control limit

Summary

1. Understand the basic anatomy of charts used in QI: run charts and process control charts.

2. Understand some of the basics to interpreting QI charts.
Quality Improvement Charts

- References
Value in Inpatient Pediatrics (VIP) Network

(www.aap.org/quiin/vip)

The VIP Network is a healthcare stewardship organization which improves the value of care delivered to any pediatric patient in a hospital bed by helping providers implement clinical practice guidelines and other best practices, with a special focus on eliminating harm and waste caused by overutilization.

Visit A Quality Collaborative for Improving Hospitalist Compliance with the AAP Bronchiolitis Guideline (B-QIP) (www.aap.org/quiin/vipbqip) to view recent improvement strategies for bronchiolitis care.
Hospitalists are fast becoming the “go to” leaders for inpatient education… It’s a great time to be a pediatric hospitalist!

Ricardo Quinonez, MD, FAAP
Section Chairperson

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