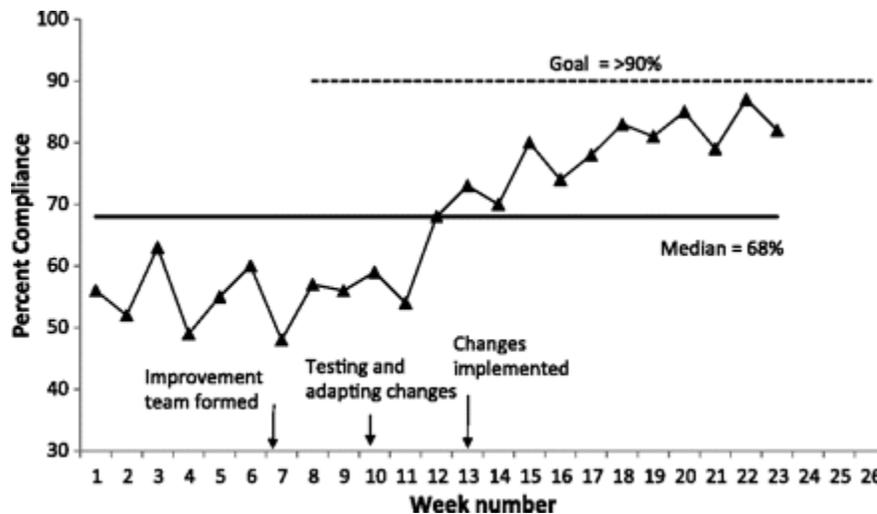# Run Chart

A run chart is a graphical display of data plotted in some time order. Viewing data over time (dynamic) rather than as summary statistics (static) yields richer, more timely data and more accurate conclusions for improvement projects. The horizontal axis is most often a time scale (days, weeks, months, quarters, etc.). The vertical axis represents the quality measure being studied (e.g. infection rate, number of patient falls, readmission rate). The median is calculated and used as the chart's centerline. Run charts help us understand and visualize the impact of different interventions and tests of change in real-time and over time. To determine objectively when these data signal a process improvement, the median and run chart rules are utilized. Goal lines and annotations of changes and other events can also be added to the run chart. Below is an example of a run chart demonstrating compliance with a standard procedure.

When to Use a Run Chart

- As a **core tool** for improvement projects to
    - Help formulate aims by illustrating current state/how the current process is performing
    - Accurately assess whether changes you are making are resulting in true improvement as you make them
- To accurately identify process variation and avoid incorrect actions
- To effectively communicate results of your improvement efforts

How Run Charts Are Constructed

1. Obtain a set of ≥ 10-15 data points in time sequence and plot them in a line graph.
2. Draw the vertical and horizontal axes, leaving room on all sides to title and label the graph.
3. Label the vertical (Y) axis with the name of the measure (e.g., % of births by C-section, Number of Days to Third Next Available Appointment, etc.).
4. Label the horizontal (X) axis with the unit of time or sequence in which the numbers were collected (e.g., April, May, June, etc., or Quarter 1, Quarter 2, etc.).

5. Determine the scale of the vertical axis. The scale should extend from a number 20% larger than the largest value to a number 20% smaller than the smallest value. Label the axis in equal intervals between these two numbers.
6. Plot the data values in the sequence in which they occurred.
7. Draw lines to connect the points on the graph.
8. Calculate the median of the plotted numbers and draw the line on the graph.
9. Title the chart, and note the goal line and the sample size.
10. Annotate the chart, indicating when key tests of change were initiated.

Note: A good technique in creating a run chart to learn about the impact of changes is to identify an initial median using baseline data. If the baseline data come from a process exhibiting no signals (shift, trend, runs, astronomical data point), extend or 'freeze' this initial median into the future. By using baseline data and extending the median into the future, new data are not allowed to influence the initial median. Any changes in the new data stand out against the baseline median more clearly and this allows for more accurate detection of signals of improvement (the probability-based rules are relative to this median value). This is particularly important as you try to understand the impact of different changes to a system over time.

Run Chart Analysis Rules to Detect Special Cause Variation

To avoid inaccurate analysis of run charts (and potential tampering/incorrect actions) three probability-based rules are used to objectively analyze a run chart for evidence of non-random (special cause) patterns in the data based on an α error of $p<0.05$. Rule 4 is based on identifying a point that is highly unusual. With accurate analysis of your data you are able to determine appropriate actions to achieve the improvement you are striving for.

Rule 1—Shift

Six or more consecutive points *either* all above or all below the median. Values that fall on the median do not add to nor break a shift. Skip all values that fall on the median and continue counting.

Rule 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 1st point and ignore the repeating values; like values do not make or break a trend.

Rule 3—Runs

A non-random pattern is signaled by too few *or* too many runs, or crossings of the median line. A run is a series of points in a row on one side of the median. If only chance is influencing the process being measured with a run chart, then there should be a regularity at which data points go above and below the median to satisfy this condition. Some points can fall exactly on the

median line, which makes it hard to decide which run these points belong to. An easy way to determine the number of runs is to count the number of times the line connecting the data points crosses the median and add one. Tables of critical values are used to determine if too many or too few runs exist.
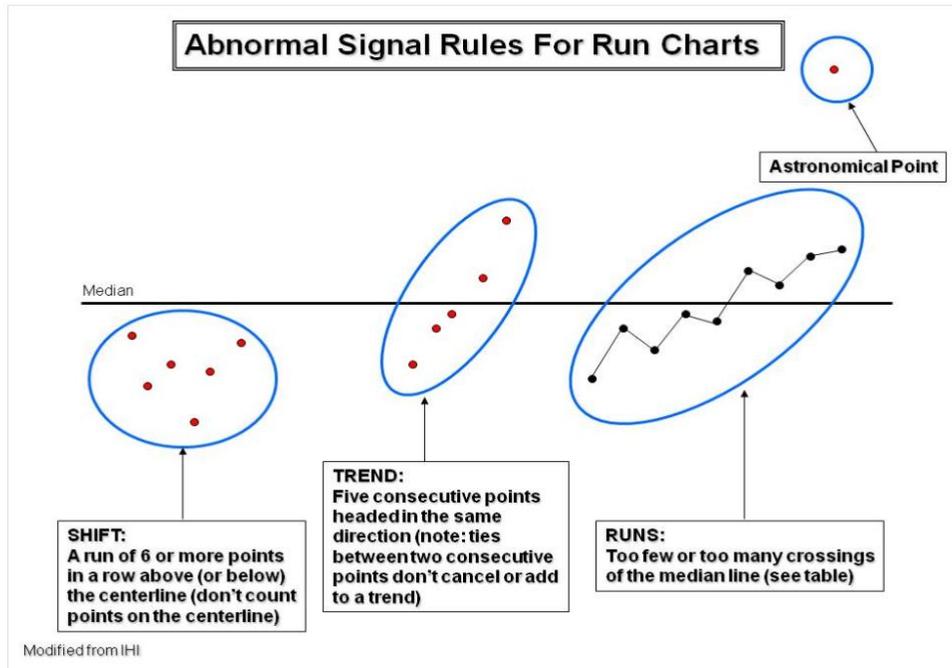
Rule 4—Astronomical Point

An astronomical data point is one that is obviously different from the other points; all studying the chart would agree the point is unusual. Don't confuse astronomical points with the highest or lowest data points, which every run chart has. Rules 1, 2 and 3 are probability based however Rule 4 is subjective and recognizes the importance of the visual display of the data in a run chart.

A whiteboard video on run charts and an instructional module-IHI module QI 103, lesson 2-can be viewed at **http://www.ihi.org/education/ihiopenschool/courses/Pages/default.aspx. Video: http://www.ihi.org/education/IHIOpenSchool/resources/Pages/BobLloydWhiteboard.aspx#FC.**

An on demand presentation on run and control charts can be viewed at http://www.ihi.org/education/WebTraining/OnDemand/Run_ControlCharts/Pages/default.aspx

A run chart template can be accessed at **http://www.ihi.org/offerings/IHIOpenSchool/Courses/Pages/PracticumForms.aspx**

Christine M. Walsh-Kelly MD   9-13-16