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Abstract:

The ability to determine if a change in a system is actually an improvement—or worsening in function—is one of the essential desiderata of quality improvement efforts. There are many ways to look at the issue. A special problem occurs when the event being studied is low frequency by nature. By way of example, patient falls in a given hospital or division of a hospital may occur in a way that is low frequency—yet each event is important. Process engineering has developed an approach to low frequency events. Part of this approach may involve specialized charts that look at the "time-between-events"—as known as geometric or "G charts". Time between events charts (G charts) are a form of statistical process control analysis with a special niche for the analysis of low frequency events that occur over time. G-charts have been used in a variety of healthcare applications. Many current statistical software packages have G chart capability.

Introduction :

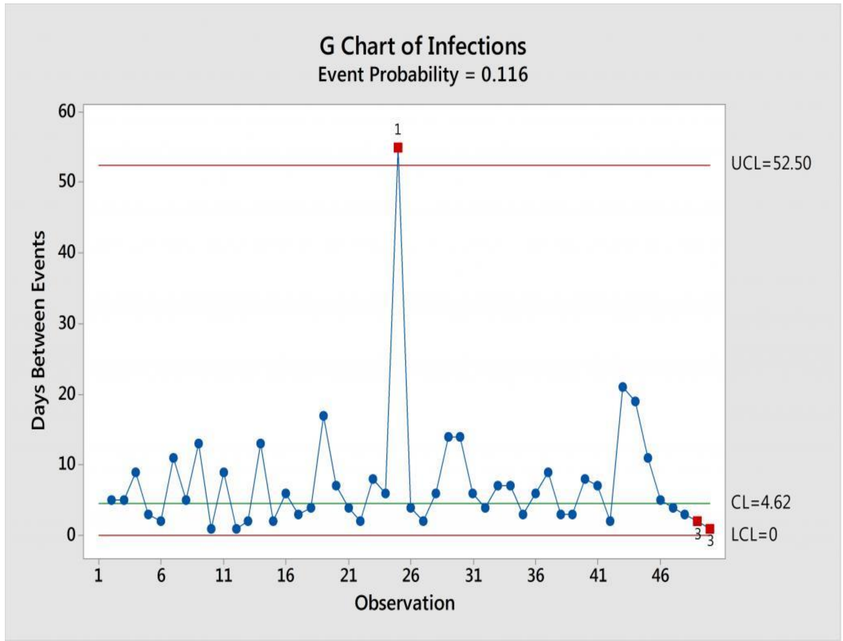
The ability to determine if a change in a system is actually an improvement—or worsening in function—is on of the essential desiderata of quality improvement efforts. There are many ways to look at the issue. However, it is important to note that pre and post testing with traditional statistical testing may be rather deceptive. For example, there may have been an improvement in function in the pre intervention system and a decline in the post intervention—but the overall picture may look like improvement. Another limitation of straight-forward pre and post intervention testing is that it may not allow for real-time analysis. For that reason, charts with data plotted against time, such as "run charts" and run charts with statistical guideposts (such as control charts) have been developed for the analysis of a wide variety of healthcare processes.

A special problem occurs when the event being studied is low frequency by nature. By way of example, patient falls in a given hospital or division of a hospital may occur in a way that is low frequency—yet each event is important. The falls may not occur every day or every week—or even less frequently. One can compare that to a laboratory metric of some sort, where hundreds of similar events may occur daily with much more relatively common defective events.

Process engineering has developed an approach to low frequency events. Part of this approach may involve specialized charts that look at the "time-between-events"—as known as geometric or "G charts".

No Conflict of Interest:

There was no funding related to this case report. The authors declare that they have no conflicts of interest.



Example of a G chart. (Bing.com) Note that the "spike" is desirable (longer time between events) and that events at the end of the series are moving in the undesirable direction. The upper control limit and the lower control limits are displayed.

Discussion:

What is a G chart?

As an illustrative example, let us use the example of a hospital that has engaged in a fall prevention program. The hospital knows that there are only a limited number of falls per year and so that if the data is plotted weekly there will be many weeks with no falls. Similarly, there may be months where the fall rate is zero. Because of the high-risk nature of falls, the hospital wishes to decrease falls as much as possible—ideally to a fall rate of zero. The hospital decides to add an additional method of analysis—the G chart—where the time between falls is plotted. By looking at the time between evens, the hospital is able to look for what are called "spikes"—which would represent in this case the desirable outcome of longer periods between fall events.

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Discussion:

•What is a rare event?

•Criteria for a rare event vary, but a common notion is that if less than 20% of the samples yield a count (for example, if less than 20% of weeks have a fall) than this could be an indication for a G chart.

•There are other indicators that are more intensively mathematically-based---and have to do with whether certain expressions of probability based on the data bring the "lower control limit" close to zero. These control limits bound upper and lower preset probability limits of a geometric distribution. Many computer software packages do these calculations and produce these boundary lines automatically. Where $\bar{g}$ represents the average days between events (falls, infections) and k is the number of values for days between events the centerline (akin to the average, but somewhat different because the chart is that of a geometric distribution)—the formula for the centerline is:

$$\bullet \bar{g} = \frac{\sum g_i}{k}$$

•The formulae for the upper control limits and lower control limits are as follows:

$$\bullet UClg = \bar{g} + 3\sqrt{\bar{g}\,(\bar{g}+1)}$$

$$\bullet UClg = \bar{g} - 3\sqrt{\bar{g}(\bar{g}+1)}$$

Examples of G-chart use in the healthcare literature:

Glenn et al report the impact of a surgical wound infection bundle in the context of pediatric cardiothoracic surgery. Because surgical wound infections fit the criteria for low frequency, part of the assessment of the work was done with G charts. The line above the run data is the upper control limit. The lower control limit is zero and hence cannot be visualized. (Glenn, Nelson)

•Statistical software package can calculate flags for events that represent certain worrisome patterns of data points. These can be assessed to see if they should have further analysis as "special cause events". (Neuberger)

Schrem et al report the use of G charts in a renal transplant program. (Schrem). Many other examples can be found in the literature. G chart use has been proposed for analysis of low frequency seizures. (Espinosa)

Conclusions:

Time between events charts (G charts) are a form of statistical process control analysis with a special niche for the analysis of low frequency events that occur over time. G-charts have been used in a variety of healthcare applications. Many current statistical software packages have G chart capability.

References:

Available on request