A Common Analytical Approach supporting Quality Improvement in Lothian

There are a number of different quality improvement methodologies that support the identification of variation and improvements in pathways and processes. In broad terms, none are perfectly 'right' or 'wrong' but have strengths or weaknesses depending on the situation being examined. Lothian Analytical Services (LAS) recommends that a standard approach is adopted across NHS Lothian so that the focus is on improvement and actions rather than the debate over methodology and statistical process. This standard approach will help to prevent the debate from weakening both the understanding and application of the quality improvement methodology across NHS Lothian.

LAS understands that similar discussions are occurring within ISD. Lothian analysts are seeking to be involved in these discussions and have also linked with colleagues within Healthcare Improvement Scotland. This may inform the approach advocated in the future as well as inform recommendations of particular charting tools.

A Methodology for Improvement

Solberg (1997) indicated that measures for improvement shared many of the same characteristics as those sought for judgment and for research; that they be valid, reliable, specific, optimally sensitive, defined and agreed. However to support the iterative nature of improvement and hypothesis testing, "good enough", rather than "perfect" data and information should be sought.

In line with this, the methodology proposed here is not one that can be unthinkingly applied to, for example, research or conferences. It is to support the clear application to quality improvement work in Lothian.

Step 1 - Pareto Charts

Pareto Charts show how often different categories of events take place. They are normally displayed as a column chart ordered with the most common on the left to least common on the right and usually display a cumulative frequency as a line on a second Y-axis. Using the 80/20 rule developed by Joseph Juran, whereby 80% of a problem can be attributed to 20% of the causes, a Pareto Chart is useful for Quality Improvement by enabling the user to focus initial change cycles on the area that is likely to deliver greatest benefit to the organisation. For example when looking at patient DNAs within a particular outpatient service a Pareto Chart would be useful to identify which clinics have the highest number of DNAs. A chart could also be developed to show the most common causes for non-attendance within the selected clinics.

Step 2- Run Charts

Run Charts identify non-random variation and are useful for conducting an initial an assessment of whether a process is appropriate for introducing change and then determining if changes applied to a process have resulted in improvement and whether they have been sustained (Perla et al, 2011). A measure is assessed in order, most often as time on the x-axis, a median plotted and a number of tests applied. Although slightly different rules are advocated for these tests in the literature, all essentially make an assessment of the pattern of variation in the measure around the median.

NHS Scotland's Quality Improvement Hub details standards in common with the IHI and the Scottish Patient Safety Programme. These are the tests will be applied for improvement work in Lothian. They differ from the rules advocated by NHS Elect in England and, to date, in Academy Training, which apply slightly more demanding tests for shifts and trends.

The QI Hub tests are outlined in the following table.

1. A **shift**: six or more consecutive data points either all above or below the median. Points on the median do not count towards or break a shift.
2. A **trend**: five or more consecutive data points that are either all increasing or decreasing in value. If two points are the same value ignore one when counting.
3. **Too many or too few runs**: a run is a consecutive series of data points above or below the median. As for shifts, do not count points on the median: a shift is a sort of run. If there are too many or too few runs (i.e. the median is crossed too many or too few times) that's a sign of non-random variation. You need to look up a statistical table (see Perla et al, 2011) to see what an appropriate number of runs to expect would be. An easy way to count the number of runs is to count the number of times the line connecting all the data points crosses the median and add one.
4. An **astronomical data point**: a data point that is clearly different from all others. This relies on judgement. Every data set has a highest and lowest. They won't necessarily be an astronomical data point. Different people looking at the same graph would be expected to recognise the same data point as astronomical (or not).

In terms of application in Lothian, for data series with less than 10 points, a median can be applied across the entire duration and updated as each new points becomes available (in The Health Care Data Guide, Lloyd P Provost and Sandra Murray, John Wiley & Sons, 2011). Once at ten points, if the process is showing only random variation, this enables a baseline median to be set which can be "frozen" and "extended" forward. If none of the signals of

non-random variation are present, the median should continue to be updated after every tenth additional point. If signals are present in initial data, this prevents a baseline median being set. Identification of the cause should be sought. Meantime the median should continue to be updated.

Step 3 – Shewhart Control Charts

Although run charts should be applied first, often there will a desire to move on to Shewhart Control Charts. Like run charts, these plot the measure and time on the y and x axes respectively and a centreline is also added, although in this instance it is the arithmetic mean rather than the median. Crucially upper and lower control limits are added to help determine the capability of the process and special cause variation.

Although there is again variation[1] in the precise nature of the test, similar approaches are advocated to identify process change in Shewhart Control Charts. Again, the QI Hub advocates tests in line with IHI.

The table below provides IHI's summary of these rules and those to be applied for improvement work.

1. **Rule #1: 1 point outside the +/- 3 sigma limits -** A point exactly on a control limit is not considered outside the limit. When there is not a lower or upper control limit Rule 1 does not apply to the side missing the limit.
2. **Rule #2: 8 successive consecutive points above (or below) the centreline** - A point exactly on the centreline does not cancel or count towards a shift.
3. **Rule #3: 6 or more consecutive points steadily increasing or decreasing -** Ties between two consecutive points do not cancel or add to a trend. When control charts have varying limits due to varying numbers of measurements within subgroups, then rule #3 should not be applied.
4. **Rule #4: 2 out of 3 successive points near a control limit (outer one third)** - Two out of three consecutive data points located close to one of the control limits (within 2 and 3 sigma) When there is not a lower or upper control limit Rule 4 does not apply to the side missing a limit.
5. **Rule #5: 15 consecutive points within 1 sigma on either side of the centreline** - This is known as "hugging the centreline"

[1] Nelson (1984), Wheeler (1993), Barr (2013), Provost and Murray (2011) and Davidge (2015) all propose alternatives, each at marginal variation to each other in terms of the specifics.

In Lothian ideally at least 20 points would to be involved[1]. Trial limits can be used from 5 or 6 points (Wheeler, 1993) but recalculated with each new point until 12 are available. Definitive limits can be being set at between 20 and 30 points (Provost and Murray, 2011).

Selecting Shewhart Control Chart

HIS outline a number of alternative types of Shewhart charts to be selected for different situations and flowcharts are available to work through this selection process. This is consistent with the majority of national and international advice and training. However, there is another school of thought, led by Wheeler (1996)[2] and with extensive supporting literature (see www.qualitydigest.com) which indicates that for most practical situations, the XmR chart provides clear results.
There are however a number of advantages and disadvantages associated with using the different charts advocated by these two schools of thought. These are summarised below.

Charts obtained via the flowcharts

Advantages

1. These charts are considered 'correct' and can provide the most exact results.
2. Control limits vary according to sample size

Disadvantages

1. Underlying assumptions in relation to the distribution of the data may not be met. These were summarised by Wheeler (1996)[3] and can be paraphrased as: • Each distinct item must have an equal area of opportunity. • Each distinct item must be classified as possessing, or not possessing, some attribute. • Each distinct item must have the same probability of that attribute than any other in the same sample as well as between samples. • Any probability of possessing the attribute within distinct items will be independent of preceding items and not occur in clusters.
2. In practice, errors are often made in the chart selection, through a lack of understanding of the represented situation.
3. Difficult to automate and apply in dashboards.
4. The distribution of this data in quality improvement work is unlikely to be sufficiently understood when improvement work commences which can lead to lack of confidence in the choice of charts.
5. Takes longer to understand and apply.

[2] Also Wheeler (1993, 2011) and Barr (2013)
[3] Also Wheeler (1993, 2011) and Barr (2013)

Xmr Charts

Advantages

1. Simple to understand.
2. To paraphrase Solberg, provides “good enough” results in most improvement situations
3. Uses empirical limits calculated from the data and does not require any assumptions about the underlying distribution of the data.
4. Quick and easy to apply to practical situations
5. Easy to automated and apply in dashboards.
6. Recommended by Wheeler, Stauffer (2010) and Balestracci (2014)
7. ‘Constant’ control limits

Disadvantages

1. Not considered ‘correct’ or completely accurate by a large number of improvement community

Therefore, taking into account the above points, LAS has made the pragmatic decision to use XmR charts in the first instance when control charts are required. However, LAS will also provide advice on the choice and application of the other charts where appropriate, for example when publication is considered or for contemporaneous comparisons between units, where funnel plots are most often deployed.

Summary

In summary, LAS recommends that NHS Lothian applies the following common approach to quality improvement work:

1. Pareto charts will be used to help identify the most suitable information to help achieve the aim of the quality improvement project.
2. Run charts will be produced to accompany any data tables. Guidance on interpreting the charts will be provided using the tests noted above
3. If required XmR SPC charts will be produced. Guidance on interpreting the charts will also be provided using the tests noted above
4. Other SPC charts will be discussed if desired.