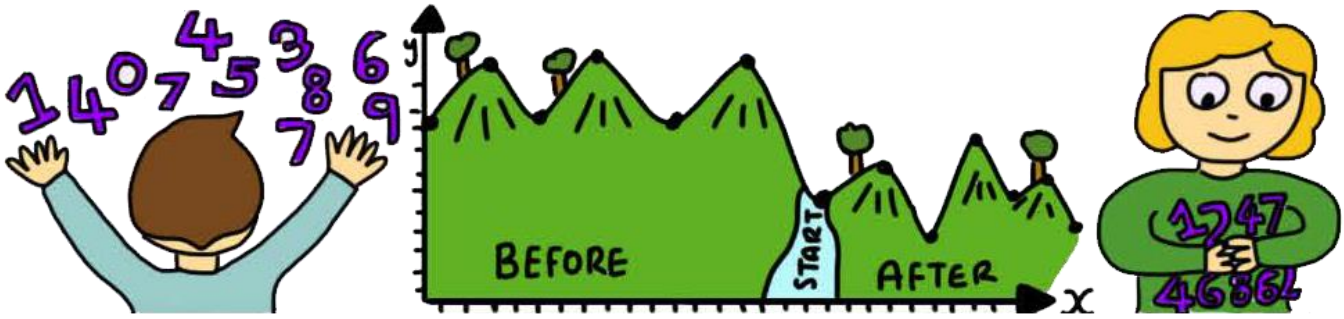
ELFT's Statistical Process Control (SPC) Charting Guidelines



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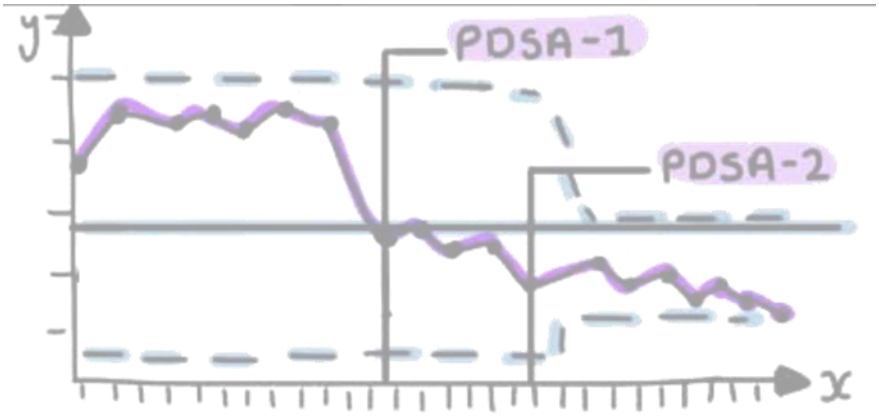


Purpose

The purpose of the policy is to ensure consistency in the way that SPC charts are used within ELFT. No matter how the chart is created, whether on Life QI, PowerBI or using QI Charts/QI Macros, the rules should all be applied in the same way.

This policy will be more of a 'FAQ' as it is assumed that you will have learned about SPC charts during one of the Quality Improvement (QI) training and might need some guidance on applying the rules.

If you have not attended any QI training at ELFT, then please speak to your manager before signing up. More information can be found at https://qi.elft.nhs.uk/.

What are the types of SPC charts and why do we use them?

There are two forms of SPC charts:

- Run charts
- Control charts – there are multiple control charts to choose from, depending on the type of data you have

We use SPC charts to look at data over time and how systems or processes change during that period. We also use them to determine if a change is improving a process, particularly when we are using improvement strategies within the system or process.

When do we switch from run charts to control charts?

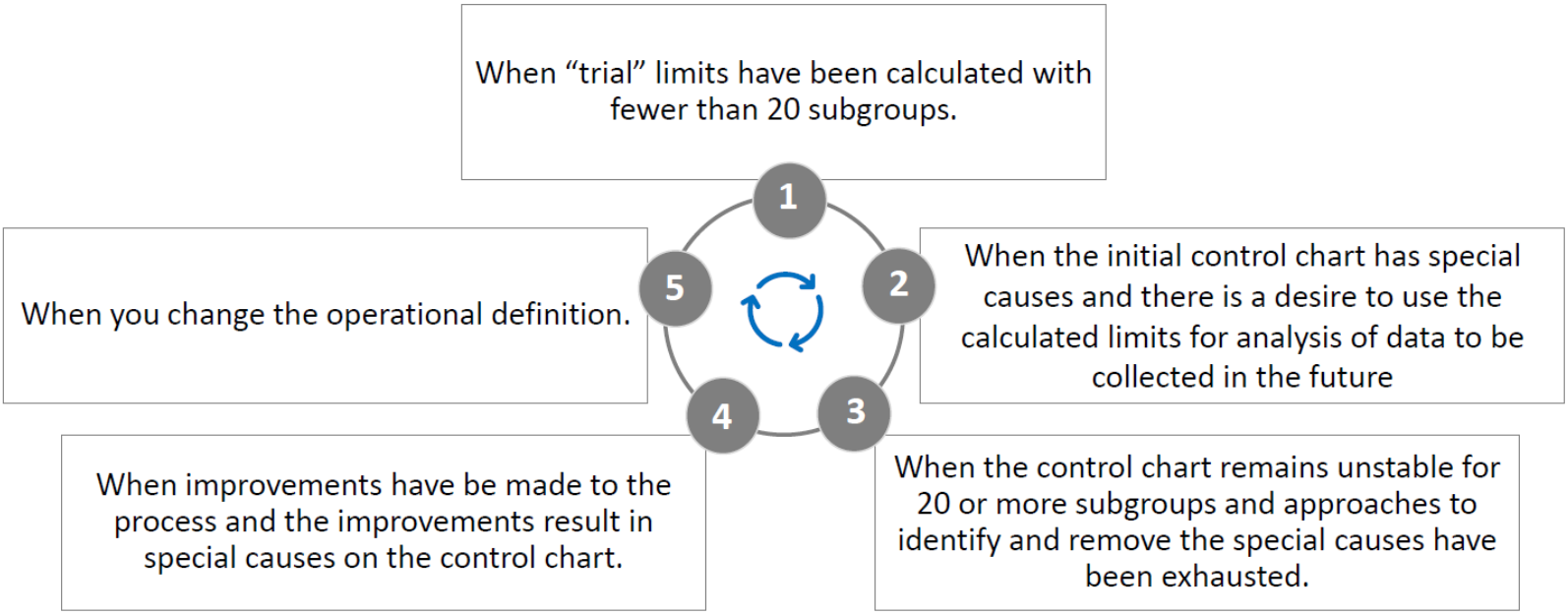
Even before creating run charts, we can simply use line charts for the first few data points to start tracking data over time. Below is a guide we go by to know when to use line charts, run charts and control charts in order to maximise the appropriate use of the underlying statistic (e.g. the median or mean). If you have…

Number of data points	Type of chart
2 to 9 data points…	You should start with a line chart
10 to 15 data points…	You should change into a run chart
15 to 19 data points…	You *can* create a control chart with "trial" limits
20+ data points…	You should change into a control chart (with set limits)

You can create a simple line chart on Microsoft Excel. At present, there is no option for creating a line chart on Life QI, so you can create a run chart on Life QI as an alternative.

When do we revise the centreline and control limits?

There are five reasons where we would recalculate limits:



What do we do when we see non-random variation on a run chart or special cause variation on a control chart?

Please see on the next two pages guidance on what to do when you see non-random variation on a run chart or special cause variation on a control chart.

RUN CHARTS

	DESCRIPTION	BEST PRACTICE	EXCEPTIONS
Baseline Data	Baseline data helps you to see how your system process is currently performing. It is collected before any quality improvement work is done. It then allows you to compare results from your improvement work to see how much of an impact your work has had. This data can also be collected retrospectively.	A minimum of **10-15 baseline data points** is advised to give you an accurate representation of how the system is performing.	On some occasions, you may not have 10 data points. In such cases, you can use fewer data points if you are confident that the baseline median is an accurate representation of how the system is performing. If you are not sure, please speak to your respective QI coach or Improvement Advisor (IA) for guidance and support.
Non-random variation	If you see a non-random variation signal on your run chart ***(refer to appendix 1)***, it means that your system has been influenced by factors or processes that may limit the amount of control you have on the system. These signals include: • Shift • Trend • Too many or too few • Astronomical point	If you see any of the four non-random variation signals, you need to look at your data and investigate what may have caused this. If the non-random variation signal you are seeing is a shift (**6 or more consecutive data points** above or below the median), you need to recalculate the median.	If you are not sure, please speak to your respective QI coach or Improvement Advisor (IA) for guidance and support.
Recalculating the median	When the current median value does not accurately represent how the system is performing now.	**WHEN** When you see a shift in your data (**6 or more consecutive data points** above or below the median).	If there was an external event that has affected your data, you can recalculate the median to cater for this. For example, you might change the operational definition of the measure which would impact the results you are plotting. In such cases, you can recalculate the median as your system has changed. If you are not sure, please speak to your respective QI coach or IA.
		HOW When recalculating the median, we advise you to base the new median on the **first 6 data points only**. The reason for this is because this new median becomes your new baseline data, allowing you to continue to do improvement work without the median moving up and down as you enter new data.	On some occasions, you may decide to include more data points in the median calculations. You are the subject matter experts so if you feel more data points are needed to give you an accurate value for how the system is performing now, then you can do so. If you are not sure, please speak to your respective QI coach or Improvement Advisor (IA).

CONTROL CHARTS

	DESCRIPTION	BEST PRACTICE	EXCEPTIONS
Baseline Data	Baseline data helps you to see how your system process is currently performing. It is collected before any quality improvement work is done. It then allows you to compare results from your improvement work to see how much of an impact your work has had. This data can also be collected retrospectively.	A minimum of **15-20 baseline data points** is advised to give you accurate control limits showing the variation that is permissible within your system.	On some occasions, you may not have 20 data points. In such cases, you can use fewer data points to create your control chart "using trial limits" which can be revised once 20 data points have been reached.
Special Cause variation	If you see special cause variation on your control chart ***(refer to appendix 2)***, it means you do not have a stable system, so the average and control limits may not predict future outcomes. These signals include: • Shift • Trend • Three sigma violation • Two out of three points • 15 points or more hugging the mean	If you see any of the five special causes variation rules, you need to look at your data and investigate what may have caused this. If the special cause variation is either a shift (**8 or more consecutive data points** above or below the mean) or 15 points or more hugging the mean, you need to recalculate the mean.	If you are not sure about this, please speak to your respective QI coach or Improvement Advisor (IA) for guidance and support.
Recalculating the mean	When the current mean value and control limits do not accurately represent what the system is capable of.	**WHEN** When you see a shift in your data (**8 or more consecutive data points** above or below the mean). OR When you see **15 or more data points** hugging the mean (make sure to have a conversation beforehand)	If there was an external event that may have affected your system, you can recalculate the mean to cater for this by ghosting (see below.) If you are not sure about this, please speak to your respective QI coach or Improvement Advisor (IA) for guidance and support.
		HOW When recalculating the mean, we advise you to base the new mean on the **first 8 data points only**. For example, if you see 12 points below the mean on your control chart, you fix the mean to only the first 8 points and then extend the mean across. The reason for this is because this new mean becomes your new baseline data, allowing you to continue to do improvement work without the mean moving up and down as you enter new data.	On some occasions, you may decide to include more data points in the mean calculations. You are the subject matter experts so if you feel more data points are needed to give you an accurate value for how the system is performing now, then you can do so. If you are not sure about this, please speak to your respective QI coach or Improvement Advisor (IA) for guidance and support.

What are the rules for run chart and control charts?

Rules for both can be found on the QI microsite or in the appendixes below.

- Run chart
- Control chart

Why do we only recalculate limits during a shift and no other special causes?

Whilst control limits are set during the baseline period, if a change to the system is observed (usually indicated by the presence of a Special Cause) the control limits can be recalculated to reflect this. A minimum of 3 data points is required to recalculate the control limits, and any less than 10 will trigger a warning that more points are advised

If we recalculated limits every time there was a special cause, how would the chart look? Especially within an unstable system or process.

We only recalculate limits when there is either a shift upwards or downwards because a shift gives us an indication of a stable process, showing a change in the system. A trend gives us an indication that the system is not stable, not that there has been any change in the system overall.

Recalculations of the limits after a shift is not the end. We then gather the thoughts and opinions of the team doing the improvement work (subject matter experts) as to why this has happened. We gather a **narrative** around what has happened and why. This is vital as it can help the team to tell their story and learn from it.

How can I get access to QI charts and/or QI macros?

To get access to one or both, you will need to contact IT (via the service desk or calling them) and ask them to get it installed for you.

Both can create SPC charts for you but not all types of charts are available on one, so it is advisable to get both installed so that you are covered in all cases.

Please refer to guides online and on the software themselves for instructions on use.

What if you have narrow control limits on a P chart and U chart?

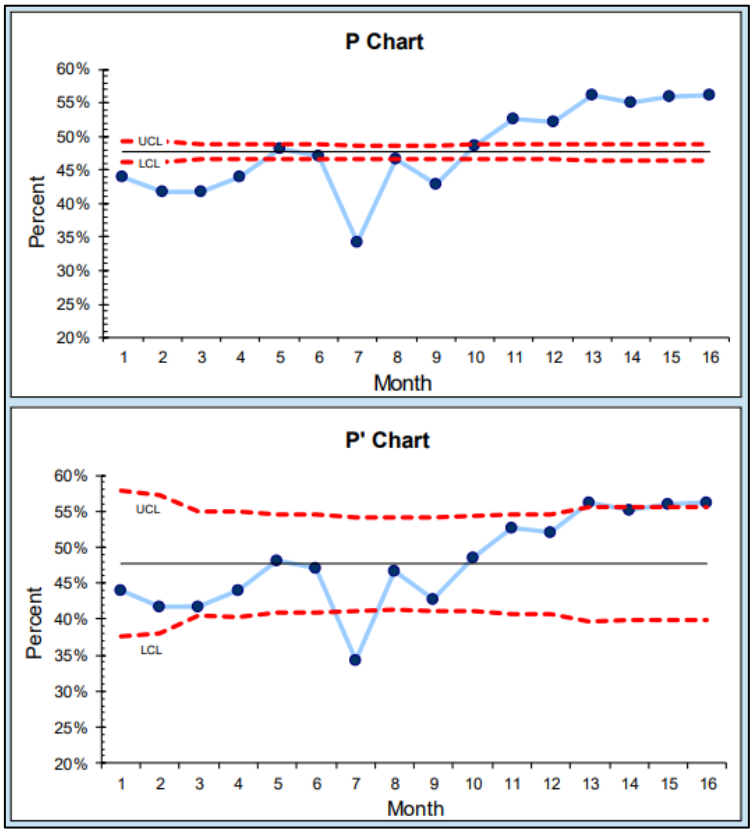
If you have created a P chart or a U chart and the limits look really narrow and most of the data points are outside of those limits, you will need to re-create the chart in question. This tends to happen when you are using large subgroup sizes in the thousands (averaging 5000+).

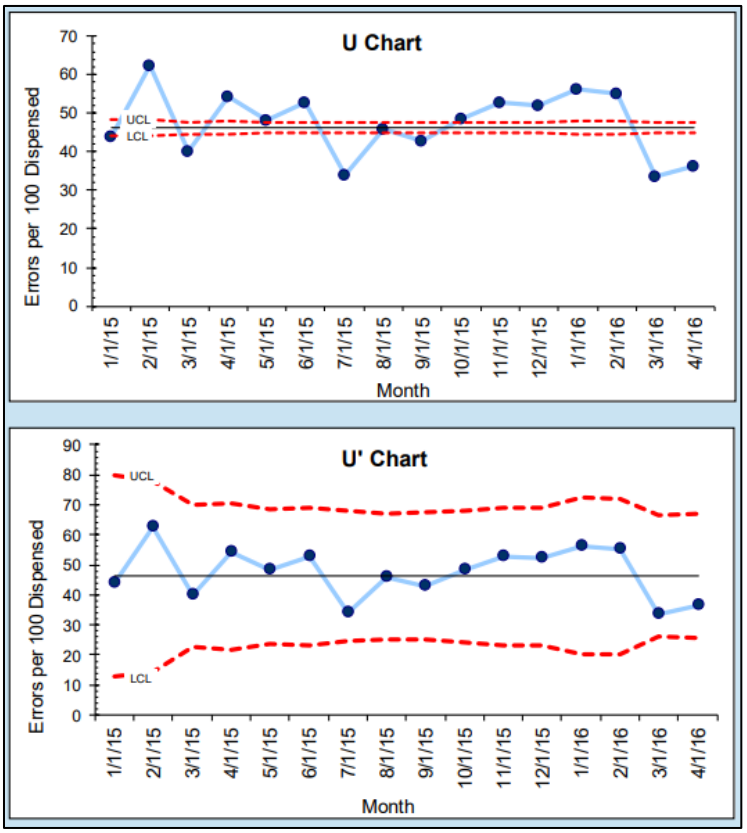
In this instance, you would need to create a P' (called P Prime chart) or U' (U Prime chart). You can see below the difference using these prime charts makes. The upper and lower control limits are wider and allow for easier interpretation of the charts.

Notes:

- In the first instance, you should always create P and U charts as normal, and only if the below situation occurs, then you use the prime charts
- This situation should only occur for P and U charts. If you see narrow limits on any other control charts, you should as a first step, look at the raw data and ensure that appropriate baselines are set

You can use QI charts/QI macros to create these prime charts.





What should you do if you have too many data points on '0'?

When you create an SPC chart and notice that there are quite a few data points on '0', **particularly 20% of the data or more**, you would need to consider whether the chart used is the correct one as it makes it harder to draw any interpretations from the chart. This suggests that the data you are looking at is relating to rare events – events which do not happen every week or month or for months at a time, so please also do consider if your sub-group approach is correct too, e.g., instead of looking at incidents by hours or seconds, measure it by weeks or months.

These rare events cause normal SPC charts (P chart, C chart and U charts) to be ineffective and it becomes questionable to use these charts. In these cases, there are two specialist charts that you can use – a T chart and a G chart.

A 'T chart' looks at the **time between rare incidents** occurring. A good example of when this chart might be useful is looking at the time between unexpected deaths in a hospital. We would hope that these are far and few in between and if we plotted this as monthly data on a C chart, we would see many '0' data points for months and months. This would not give us any meaningful to use to interpret. If we instead looked at the time, typically in days, between these unexpected deaths, we would get a better idea of what is happening within the system as there would not be any '0' data points as you just require the dates of the rare incidents occurring and all SPC charting software will calculate the number of days for you on the chart.

A 'G chart' looks at the **number of opportunities between rare incidents** occurring. A good example of this chart is looking at the number of cases between medication errors or cases between infection on a ward. Like a T chart, it will give you a better idea and understanding of what is happening in your system and processes as there would not be any '0' data points and allow for better interpretation.

When do you ghost data points?

At times, there may be data points which are not representative of the system or process that affect the chart. For instance, over the Christmas period, there may be less referrals received, which is not indicative of your actual system. The cause of the lower number of referrals is because of the holiday period.

In situations like this, you can ghost the data point. Ghosting means that the data point is still shown on the chart but is removed entirely from the calculation of the median (run chart) or mean (control chart).

Please ensure that you speak to your team before ghosting a data point, as your own interpretation may differ to that of your team. All SPC software has (or will have) the

capability to ghost data points. Please speak to your Improvement Advisor if you require further guidance and support around this.

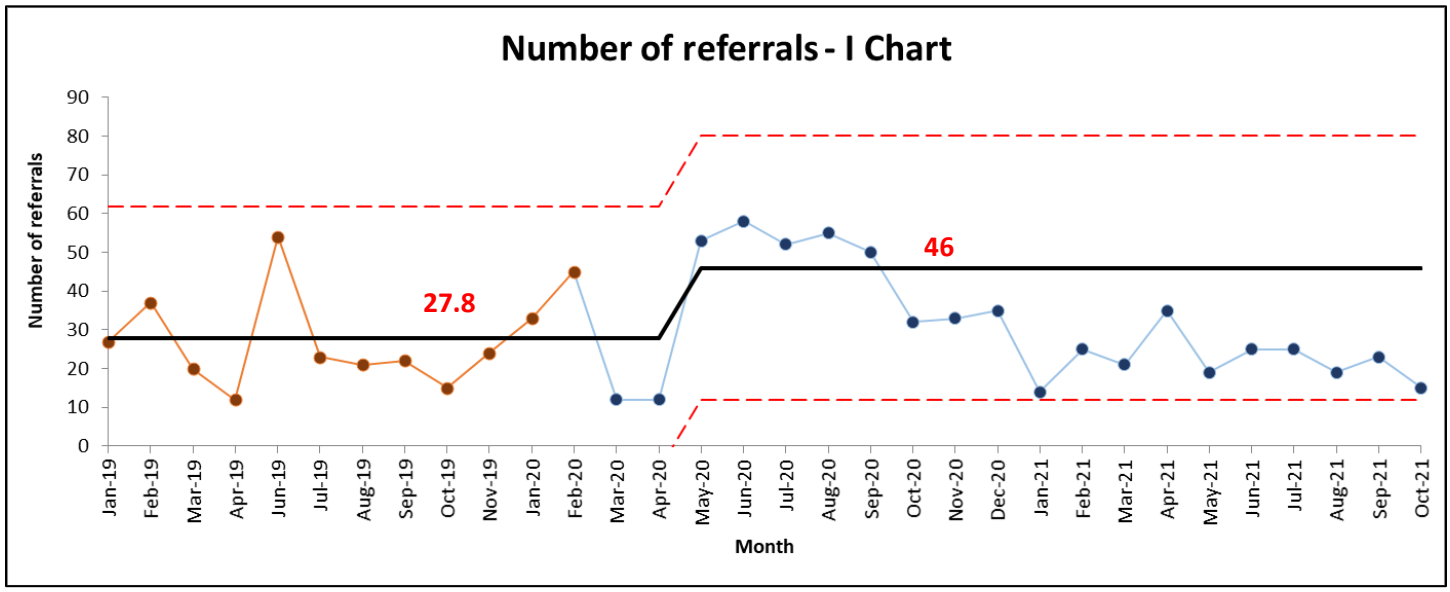
You can also ghost data points in reason number 2 of when we recalculate limits.

What do you do if you see a shift within a shift? ('Shift-ception')

Note in advance that this aspect is quite technical and requires advanced understanding of SPC charts and their rules. There is also no guidance around this in any books or research, so at ELFT, we have agreed to a set of guiding principles around this for there to be consistency on how the Trust approaches this situation.

There may be rare occasions where you have recalculated the median/mean (**note that this can occur in both run charts and control charts**) due to a shift, with the last few data points of that shift being above or below the median/mean.

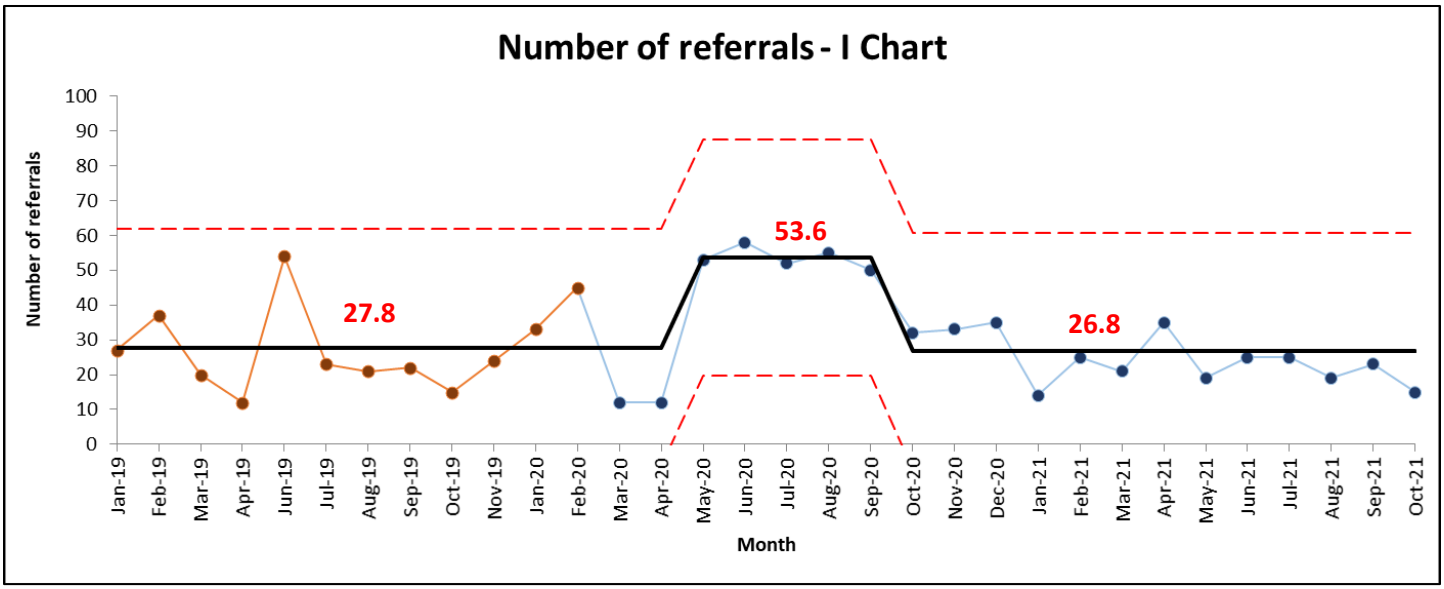
Then, as you are collecting additional data, the next data points continue to be above or below the median/mean and that leads to there looking to be another shift, using some of the previous data points of the shift where you recalculated limits. An example can be seen in the below chart.



In the above example, there is a shift upwards from the baseline from May 2020 to December 2020, and these eight data points have been used to recalculate the centreline to be 46. However, within that shift, from October 2020 onwards, there is a shift below the new centreline as all the data points after October 2020 are below the centreline.

It could in this example be argued that due to the value of the data points from May 2020 to September 2020 being in the 50s and the data points from October 2020 onwards being mid-30s to below, that this is a new shift.

So, what do you do in this situation? The limits of the chart can be recalculated again to only use the first five data points as the shift and then another shift afterwards, as below:



You can see that the above chart uses only five data points (with a minimum of four data points) for the first recalculation of the baseline, instead of eight. In situations like this, that is acceptable. But this should only be done in situations where you feel that the shift within a shift is a more accurate reflection of how your system/process is operating and that you have justification and reasoning behind your thinking.

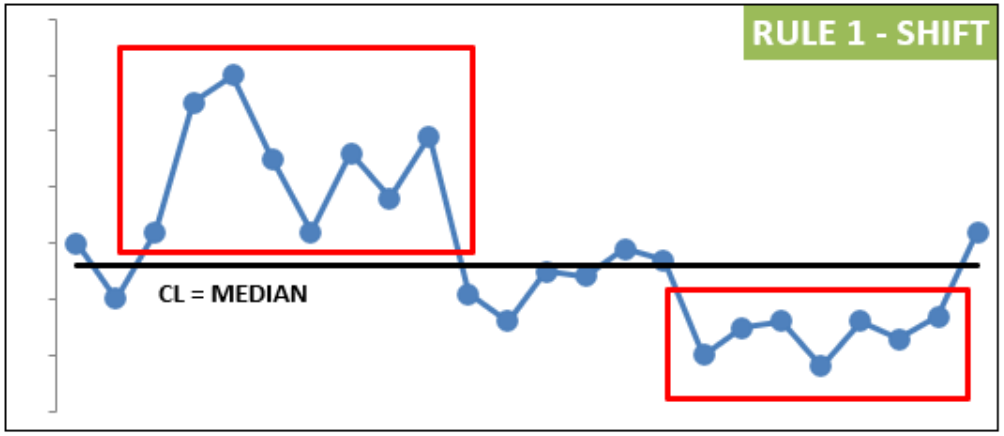
You need to always operate with the concept of using 6 (run chart) or 8 (control chart) data points to freeze first, but in the rare circumstances where change is so rapid that you see another shift creeping in (**at least four points into a shift**, you find all subsequent points are above or below the frozen mean or median), then, with discussion with the team and subject matter experts, a subsequent shift in a shift may better represent the functioning of a new and stable process (set at 8 data points).

Below are some guiding principles on what to do in this situation at ELFT:

- You need to always start with using 6 (run chart) or 8 (control chart) data points and then recalculating limits after additional data in added onto the chart
- **There needs to be a minimum of four data points for a shift within a shift** (in the above example, the first recalculation of the limits is based on five data points)
- The final shift should always have 6 (run chart) or 8 (control chart) data points
- Anything below four data points will not give an accurate representation of your system when recalculating limits
- **It is entirely a judgement call**. Just because you may see a shift within a shift, it does not automatically mean that you need to recalculate limits as above

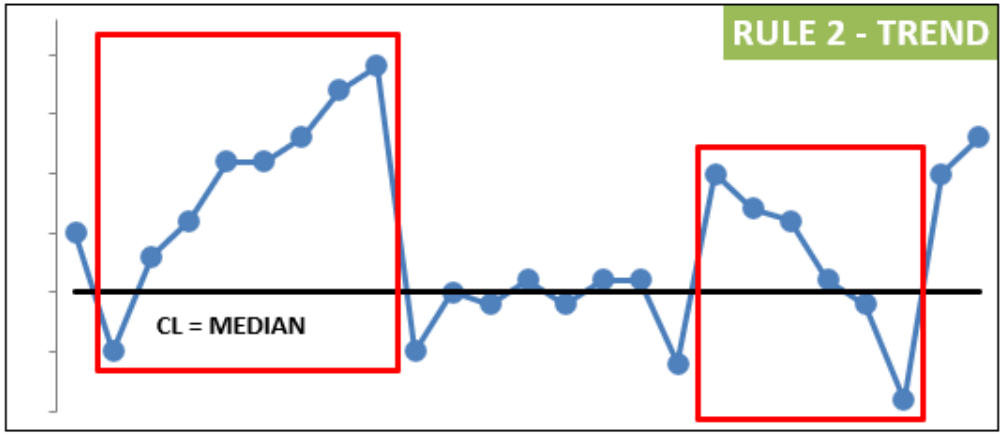
- You should consult subject matter experts if you are unsure whether there would be an accurate representation of your system and process if you recalculated limits with fewer than eight data points
- Contact the QI department (Improvement Advisors in the first instance) if you require further guidance or support around this
- These principles should be used regardless of where you are creating charts (PowerBI, Life QI or on excel with QI charts and QI macros)

APPENDIX 1 – Run Chart Rules



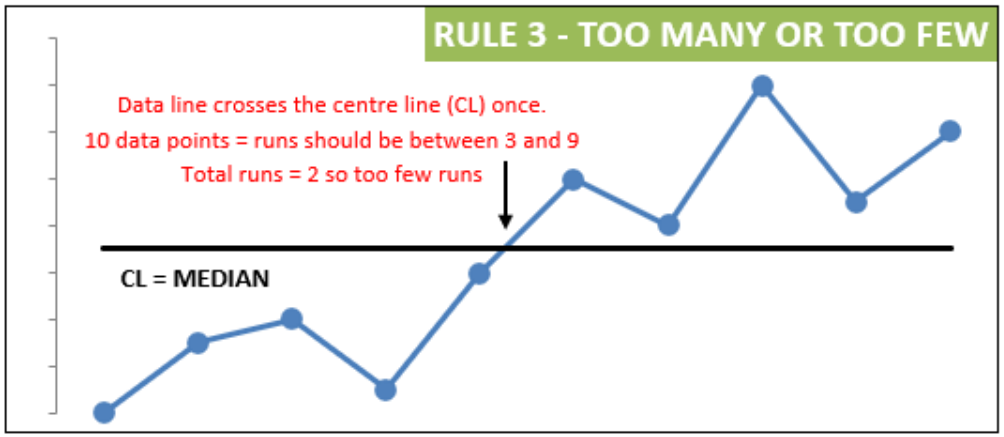
Rule 1 – Shift

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



Rule 2 – Trend

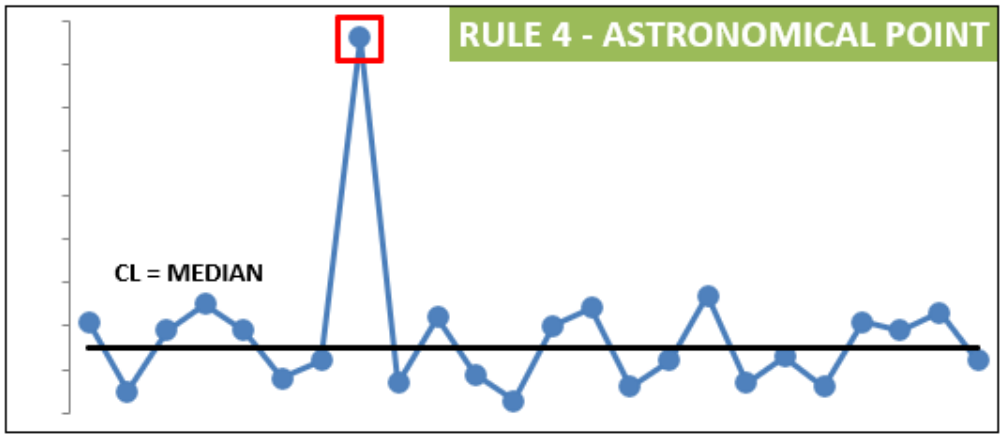
Five or more consecutive points all going up or all going down. If the value of two or more successive points is the same (repeats), ignore the like points when counting.



Rule 3 – Too Many or Too Few

If there are too many or too few runs, this is a sign of non-random variation. To see what an appropriate number of runs for a given number of data sets, refer to the table on the next page. 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. If the number of runs you have are:

- Within the range outlined in the table, then you have a random pattern.
- Outside the range outline in the table, then you have a non-random pattern or signal of change.



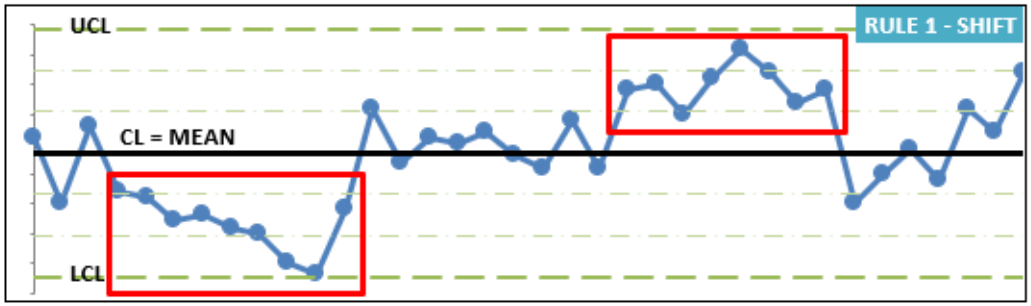
Rule 4 – Astronomical point

This is a data point that is clearly different from all others. This is a judgement call. Different people looking at the same graph would be expected to recognise the same data point as astronomical.

APPENDIX 2 – Run Chart Rule 3 Table

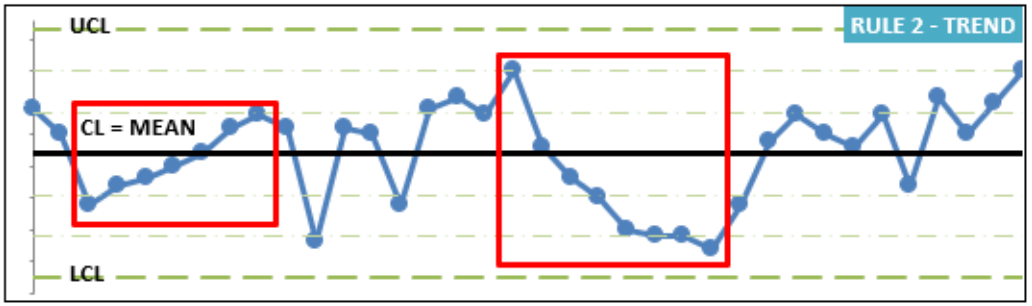
Table 1 - Runs Rule Guidance – Table for checking too many or too few runs on a Run chart					
Total no. of data points on run chart not falling on	Lower limit for no. of runs (< than this is "too few")	Upper limit for no. of runs (>than this is "too many")	Total no. of data points on run chart not falling on	Lower limit for no. of runs (< than this is "too few")	Upper limit for no. of runs (>than this is "too many")
10	3	9	**37**	13	25
11	3	10	**38**	14	26
12	3	11	**39**	14	26
13	4	11	**40**	15	27
14	4	12	**41**	15	27
15	5	12	**42**	16	28
16	5	13	**43**	16	28
17	5	13	**44**	17	29
18	6	14	**45**	17	30
19	6	15	**46**	17	31
20	6	16	**47**	18	31
21	7	16	**48**	18	32
22	7	17	**49**	19	32
23	7	17	**50**	19	33
24	8	18	**51**	20	33
25	8	18	**52**	20	34
26	9	19	**53**	21	34
27	10	19	**54**	21	35
28	10	20	**55**	22	35
29	10	20	**56**	22	36
30	11	21	**57**	23	36
31	11	22	**58**	23	37
32	11	23	**59**	24	38
33	12	23	**60**	24	38
34	12	24			
35	12	24			
36	13	25			

APPENDIX 3 – Control Chart Rules



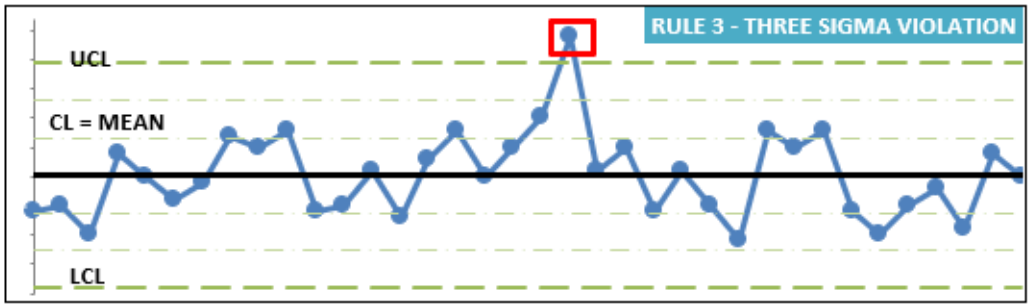
Rule 1 – Shift

Eight or more consecutive points either all above or all below the centre line (CL). Values that fall on the CL do not add to nor break a shift. Skip values that fall on the mean and continue counting



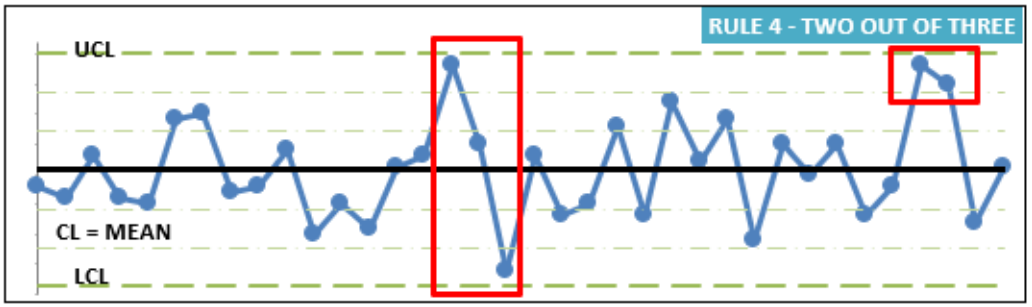
Rule 2 – Trend

Six or more consecutive points all going up or all going down. If the value of two or more successive points is the same (repeats), ignore the like points when counting.



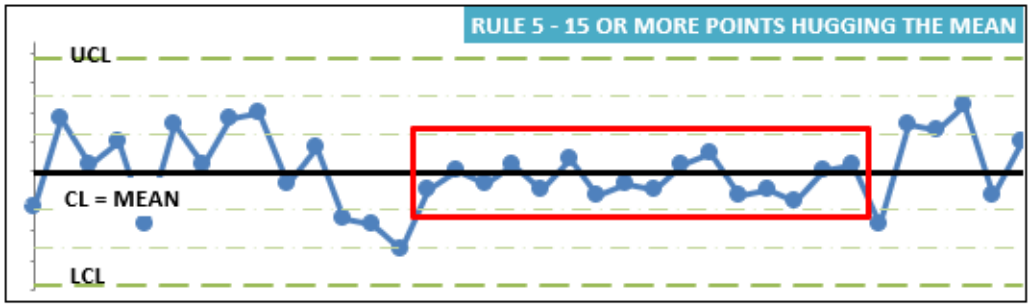
Rule 3 – Three Sigma Violation

When you have a data point that exceeds the UCL/LCL.



Rule 4 – Two out of three

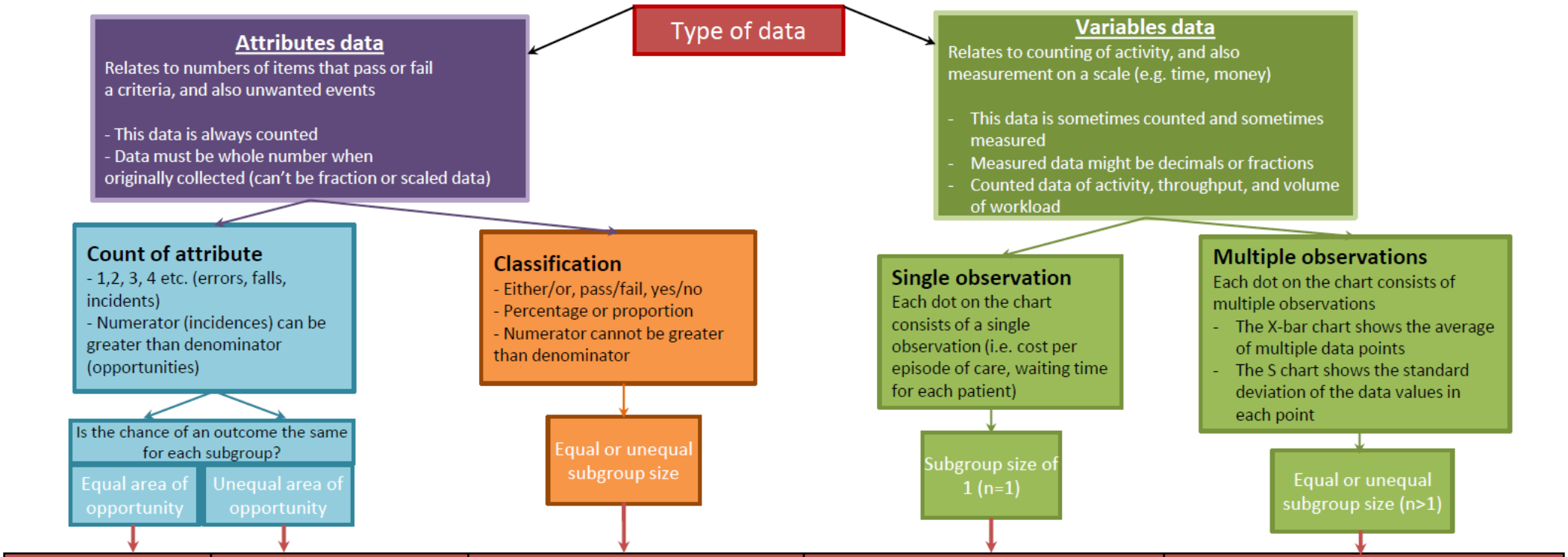
When you get two out of three consecutive points in the outer one-third of chart.



Rule 5 – 15 or more data points hugging the mean

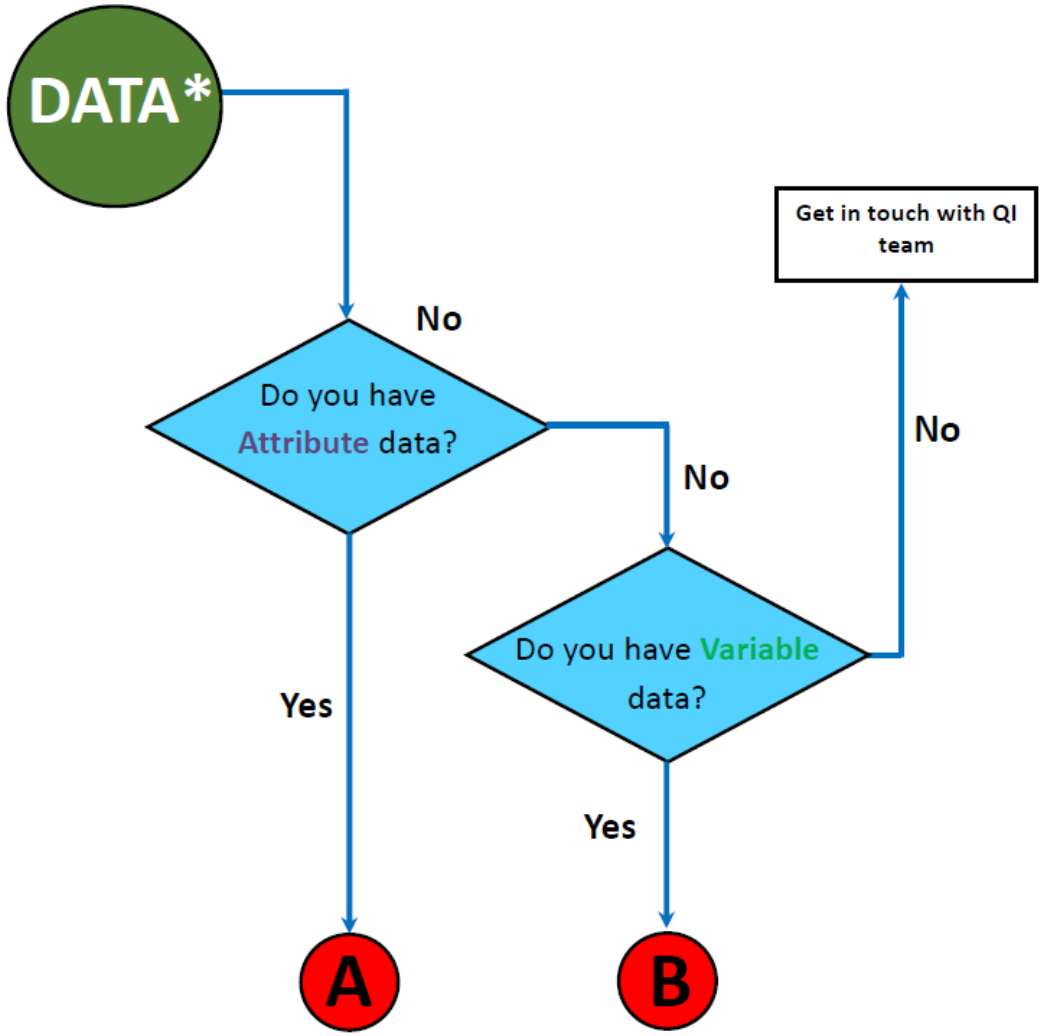
15 or more data points hugging the centre line (inner one-third of the chart). In a normal distribution, you should have around 68% of the data near the mean of the distribution (+/- 1 standard deviation). When you get a pattern like this, you're exceeding the 68%.

APPENDIX 4 – Control Chart Selection Guide



Example measures				
# falls each week # of complaints received each month	# violent incidents per 1000 occupied bed days	% staff who had a good day at work each day % or appointments cancelled each week	# of referrals received each week Temperature of clinical room recorded daily	Average time spent waiting in waiting room each clinic Average attendance at ward community meetings across the hospital each week

APPENDIX 5 – Control Chart Selection Flowchart



Attribute data can only take particular values. There may potentially be an infinite number of those values, but each is distinct and there's no grey area in between. The data can be numeric when counting unwanted events – for example *number of falls* – but it can also be categorical – such as *pass or fail, male or female, good or bad.*

Important points about **attribute** data:

- It is counted, not measured.
- Data must be whole numbers when collected (can't be fraction or scaled data)
- There is two sub-types:
  - Count of attribute data
  - Classification data

Typical examples:

- Number of falls
- Number of violent incidents per 1,000 occupied bed days
- % of missed doses
- % of service users scoring "effective" or "very effective" for patient care

*A **run chart** may be used with any type of data. It is often the starting point for viewing data over time when little data are yet available.

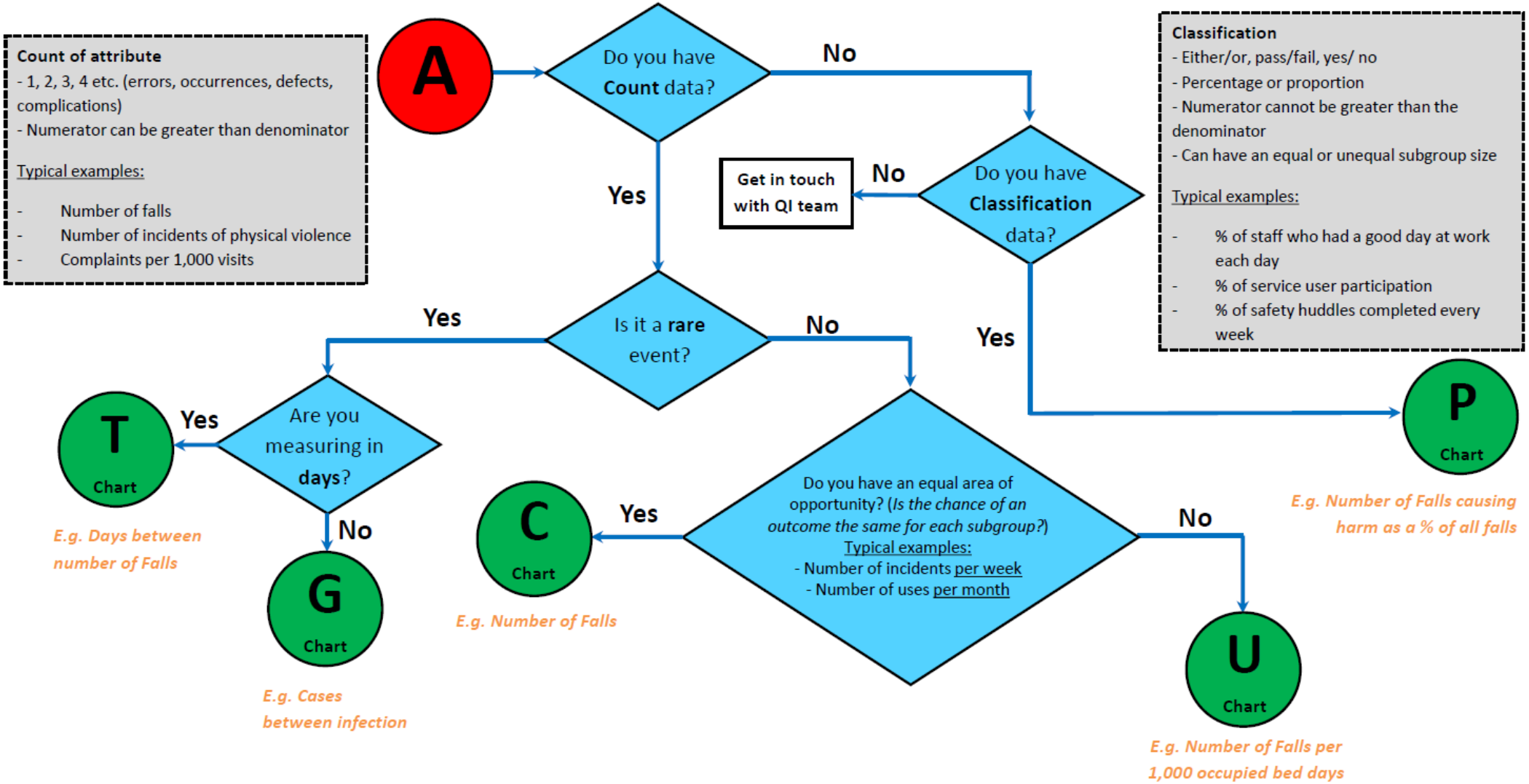
Variable data relates to counting of activity, and also measurement on a scale (e.g. time, money).

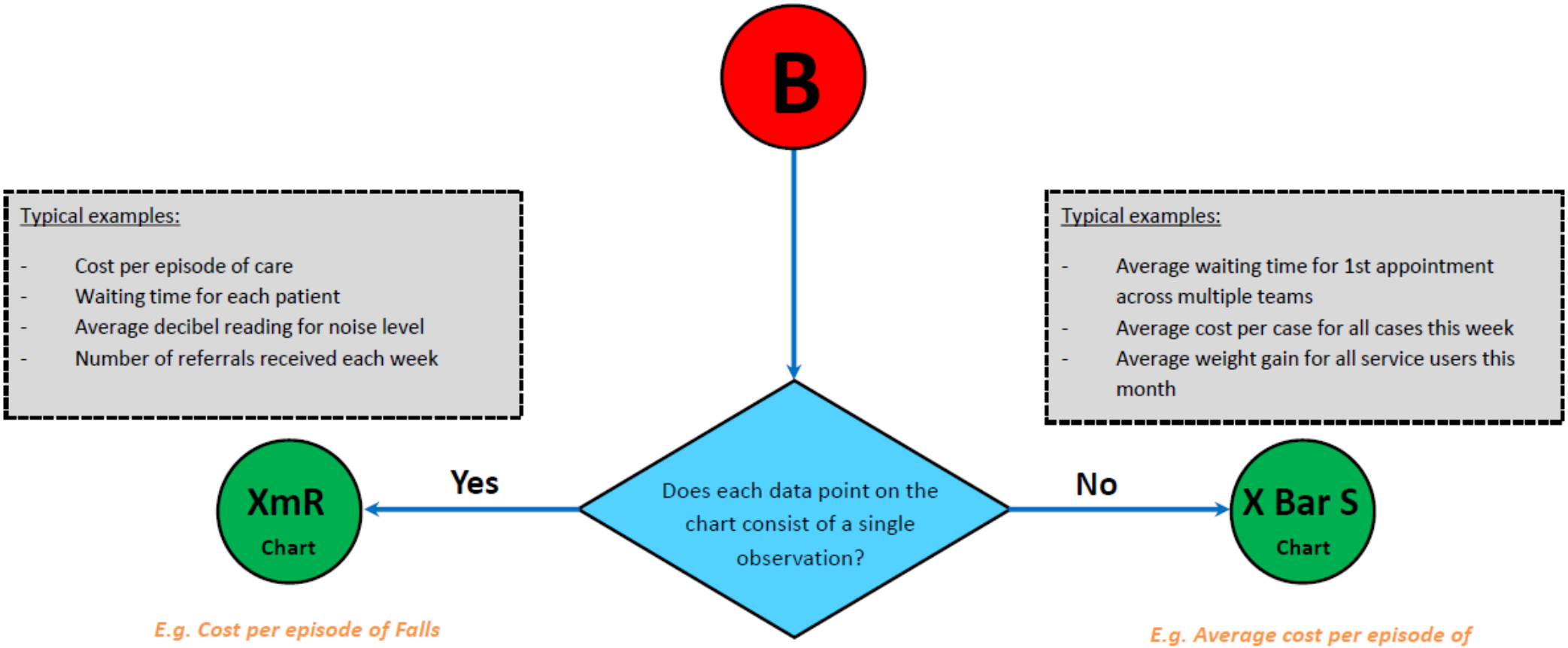
Important points about **Variable** data:

- Data is sometimes counted and sometimes measured. When measured, it might be in decimals or fractions.
  - Measurement of time
  - Measurement of money
  - Physical measure (length, height, weight, temperature)
  - Counting throughput (volume of workload, activity)
- It requires some type of scale

Typical examples

- Waiting times for 1st appointment
- Service user length of stay
- Service user weight
- Number of referrals received


Count of attribute
- 1, 2, 3, 4 etc. (errors, occurrences, defects, complications)
- Numerator can be greater than denominator
Typical examples:
- Number of falls
- Number of incidents of physical violence
- Complaints per 1,000 visits
A
Do you have Count data?
No
Yes
Classification
- Either/or, pass/fail, yes/ no
- Percentage or proportion
- Numerator cannot be greater than the denominator
- Can have an equal or unequal subgroup size
Typical examples:
- % of staff who had a good day at work each day
- % of service user participation
- % of safety huddles completed every week
Get in touch with QI team
No
Do you have Classification data?
Yes
Is it a rare event?
Yes
No
Are you measuring in days?
Yes
No
T Chart
E.g. Days between number of Falls
G Chart
E.g. Cases between infection
Do you have an equal area of opportunity? (Is the chance of an outcome the same for each subgroup?)
Typical examples:
- Number of incidents per week
- Number of uses per month
Yes
No
C Chart
E.g. Number of Falls
U Chart
E.g. Number of Falls per 1,000 occupied bed days
P Chart
E.g. Number of Falls causing harm as a % of all falls



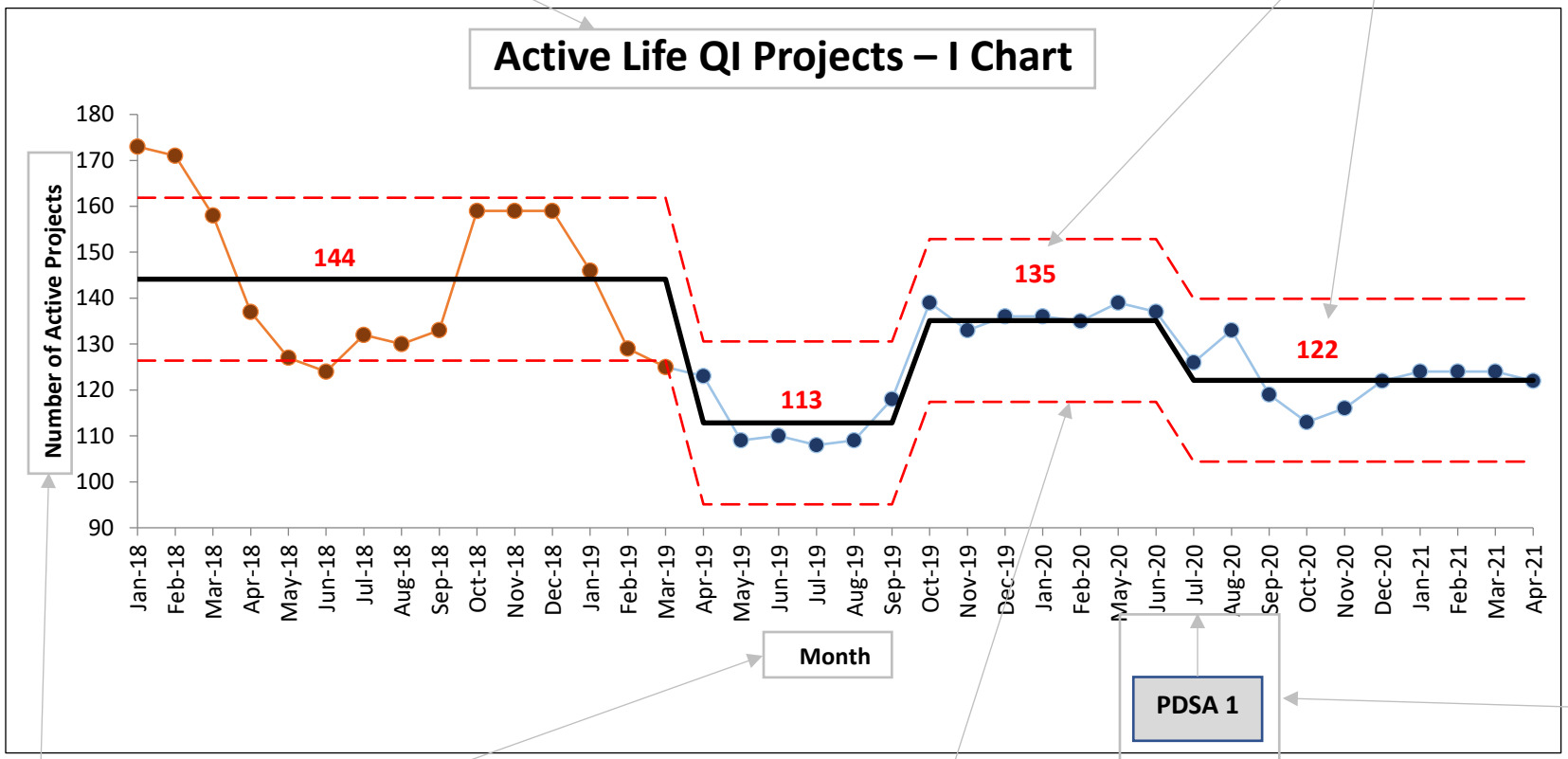
X Bar S chart characteristics:

- Two charts are created:
  - An average chart known as the X bar chart
    - Upper and lower control limit vary with sample size
    - Y-axis usually the average of a measurement
  - A standard deviation chart known as the S chart
    - Y-axis is the standard deviation of all data points making up each point on the X bar chart

APPENDIX 6 – SPC Chart formatting guide

Title of chart explains what you're measuring and the type of chart you're using

Centreline values clearly labelled in red and **bold.** Where possible, round to 3 decimal points

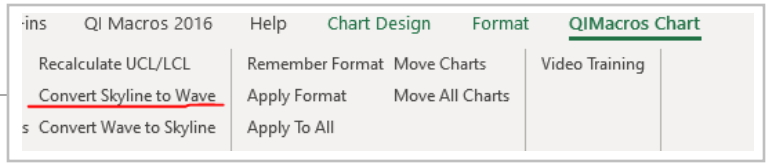


Both X and Y axis labelled clearly

Annotations added to chart to explain special cause or limit recalculations

Both UCL and LCL need to be converted to 'Wave' to look like this.

To do this, click on the chart and go to "QIMacros Chart" option (underlined in green) and click on "Convert Skyline to Wave" (underlined in red)

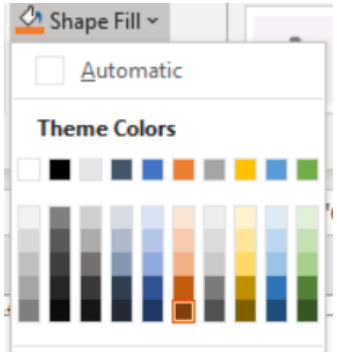


Baseline data points need to be set to a different colour than test data

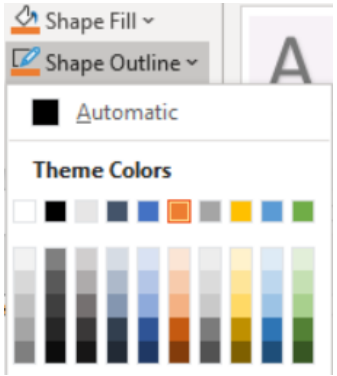
Test data points need to be set to a different colour than baseline data

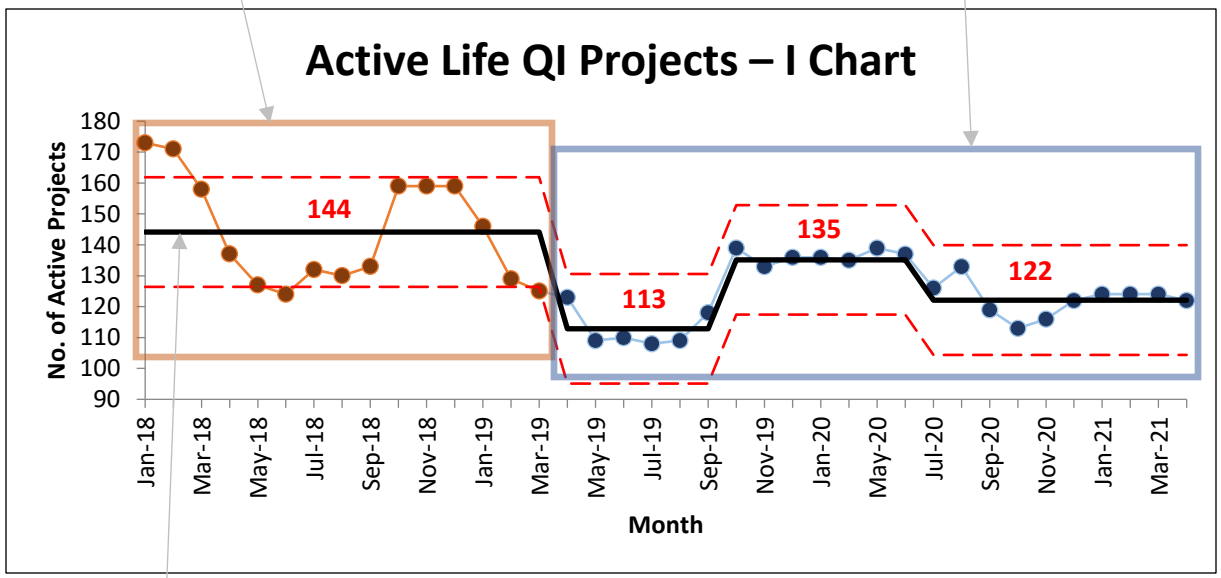
You will need to click on the datapoint and then on 'Format' to be able to change the colour of the datapoint:

Shape Fill needs to be set to the below for each baseline datapoint:



Shape Outline needs to be set to the below for each baseline datapoint:

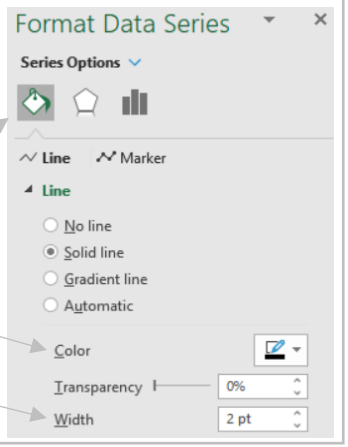




Centreline needs to be **black**, with width set to 2

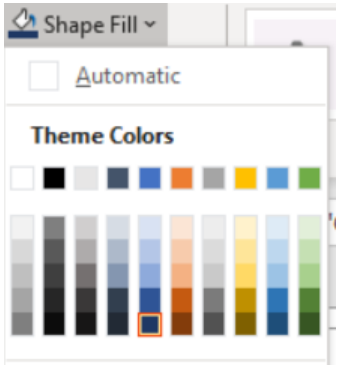
This is done by:

- clicking on the centreline
- selecting "format data series"
- clicking on the 'paint bucket'
- changing the colour to black
- changing the width to 2



You will need to click on the datapoint and then on 'Format' to be able to change the colour of the datapoint:

Shape Fill needs to be set to the below for each test datapoint:



Shape Outline needs to be set to the below for each test datapoint: