ACADEMI GWELLIANT CYMRU
IMPROVEMENT CYMRU ACADEMY

GIG CYMRU NHS WALES

Improvement Cymru Academy Toolkit Guide

Run Charts

What is a Run Chart?

Run Charts are graphs of data over time. It allows us to see whether the tests of changes we have introduced have had the desired effect and resulted in an improvement. Run charts are one of the most useful tools in improvement.

Rationale

Run Charts allow a comparison of a performance measure before and after tests of change are conducted. Which help us to see if our changes have resulted in an improvement. They make process performance *visible* to all stakeholders.

When to use a Run Chart?

A Run Chart helps teams to understand how a process is performing. They also help to understand variation in the system, which is key in making improvements in processes and systems. It enables you to monitor the performance of one or more processes over time and allow identification of signals of improvement.

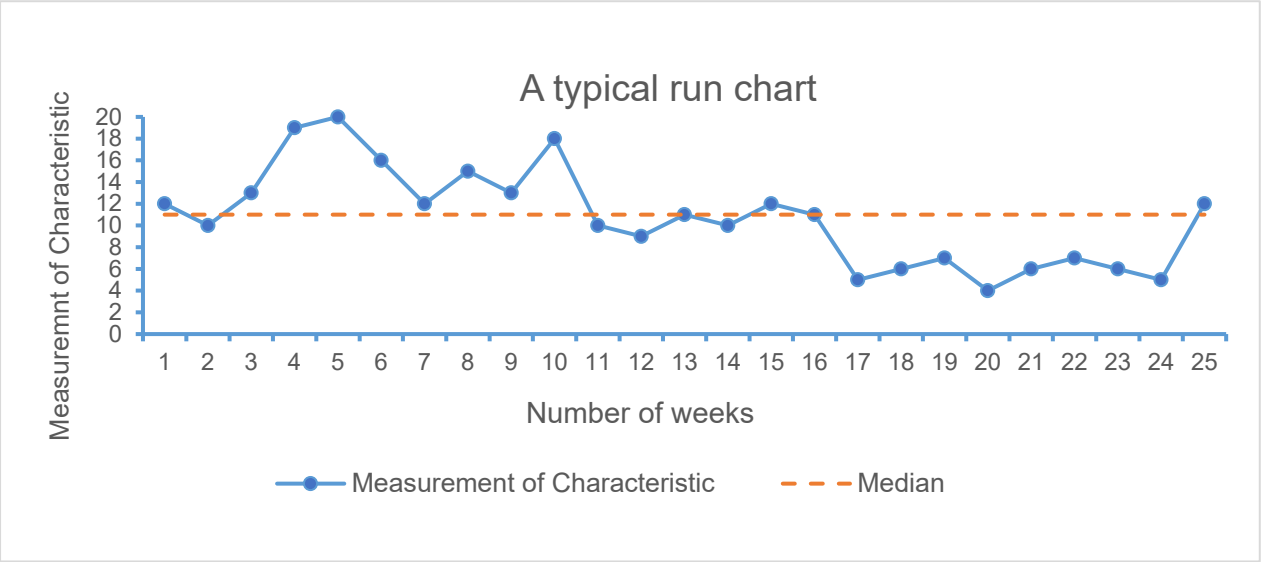
How to create a Run Chart?

There are characteristic of a run chart to be aware of:

- On the horizontal (x-axis) data is displayed in chronological order, example Jan Feb March or 1, 2, 3.
- On the vertical (y-axis) is the measure of interest, for example a count, a rate or a percentage.
- Data points are plotted on the graph and a centre line (CL) is added between the data points. The CL is called the **Median.**

Median: is the number in the middle of the dataset when the data are placed in sequential (ascending or descending) order. If the number of observations is even, the median is the average of the two middle values. The median isn't significantly influenced by extreme values in the data compared to other averages, such as mean. *(Improvement Cymru Academy Toolkit Guide Measures of central location for further information using the median).*

Diagram 1



Example: How to create a Run Chart?

1. Add a useful title that describes your data e.g. Number of people on the waiting list

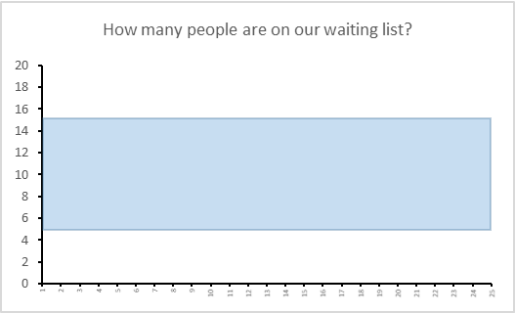
Plan data collection and start to obtain.

2. Design the horizontal axis (x)

Place a time scale, with appropriate intervals.

Cover period of interest, not just currently available data.

3. Design the vertical axis (y)



Add the measure scale, make sure there are appropriate intervals.

Most of the data will lie in the middle-half of the chart (shaded here).

Leave enough space for future changes.

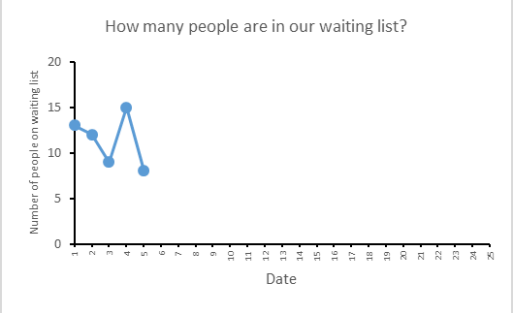
Use whole numbers.

4. Label the chart

Label your axis

Explain the x and y axis.

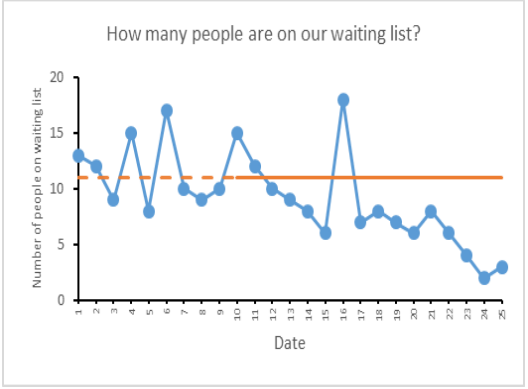
5. Plot data



As soon as you have the data plot individual points.

Connect the points by a line, from point to point in time order.

6. Plot the median

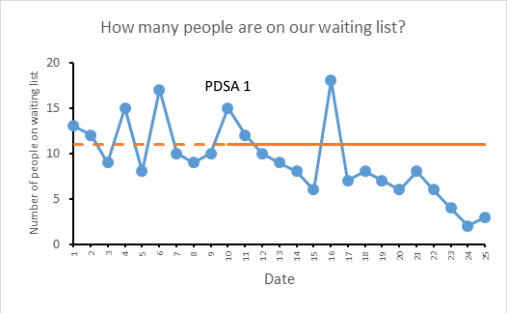


This is the middle value: half the data points above and half below.

After 10 points (we recommend you then freeze the median line and extend if no apparent changes). This helps any changes in the new data to stand out. The line changes from a dashed line to a solid line.

Can be a good indicator with fewer points (but don't use the probability-based tests and but this will affect the accuracy of your analysis).

7. Add more information.



Label the unusual events.
Mark on the place where the changes were tested (e.g. PDSA 1) or any further important information. This is known as annotation.

Interpreting a Run Chart: Variation is part of everyday life and every process has variation. However it is easy to intervene in the process to a single or most recent point. Your approach must depend on which type of variation is present.

Random Variation (Common cause): It is stable and a consistent pattern of variation, common cause or 'chance'. Typically, this type of variation occurs as a result of day-to-day variation in the process. For example, the time it takes to drive to work, the number of steps you do in a day.

Respond to this by reducing the variation – a process with limited variation will deliver standard results.

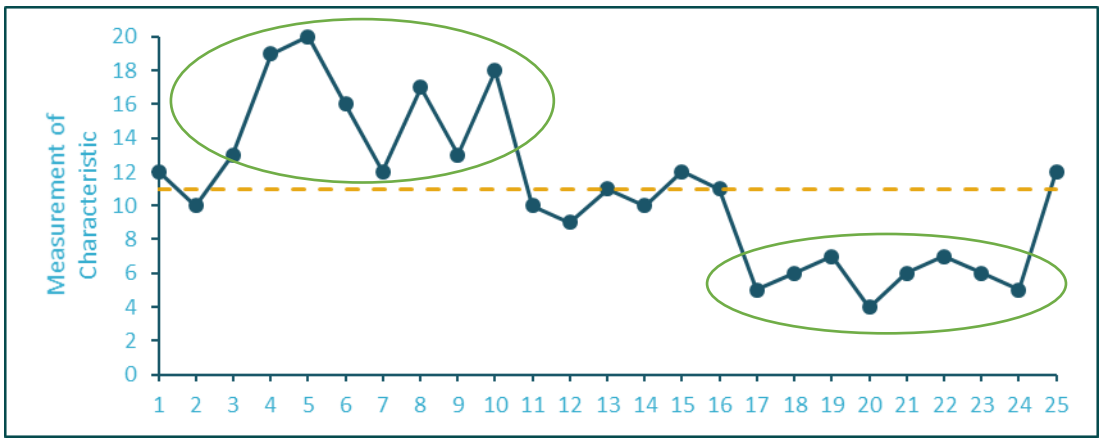
Non-random Variation (Special cause): Pattern changes over time, special cause variation or 'assignable' cause. Special cause variation is seen when changes in the pattern of data can be assigned to a specific cause i.e. performance is unpredictable. The cause may or may not be beneficial or intentional and usually occurs due to external factors outside of the process.

Respond to this by understanding: if the cause is beneficial, you may want to do more of it. If it was not beneficial, you may want to avoid it happening again.

Identifying improvement in a process

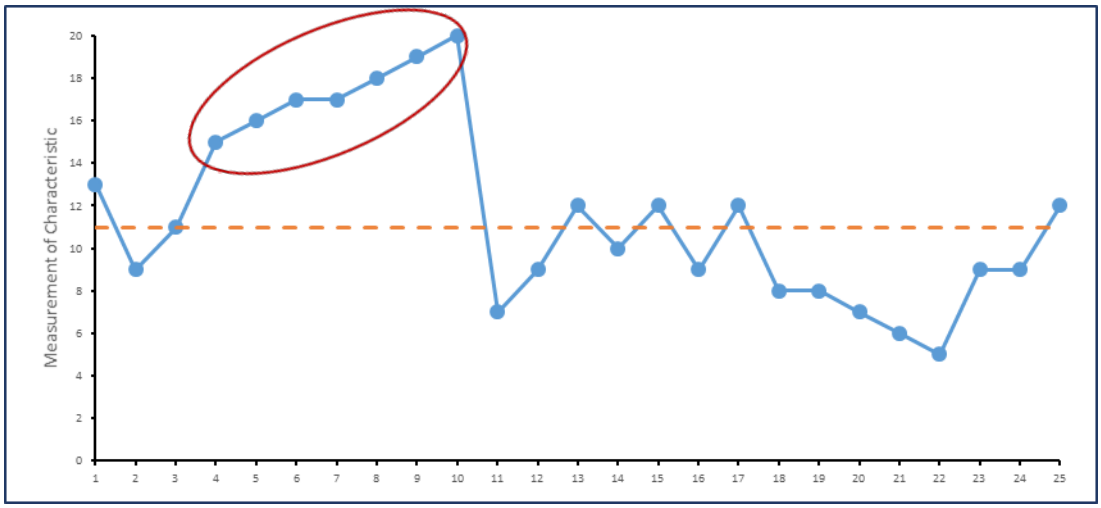
There are four rules to help you identify non-random variation. There is evidence of improvement if one or more of the circumstances depicted in the four rules below are seen when you analyse your data. To help you remember them- we have called them the **S.T.A.R**. rules (**S**hift, **T**rend, **A**stronomical point and **R**uns).

Rule 1: Shift



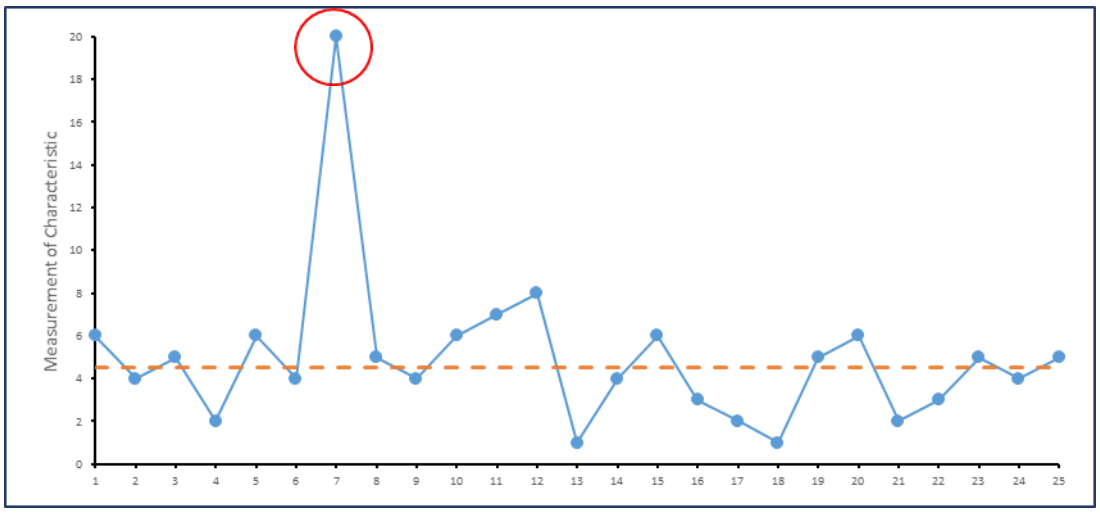
A **shift** on a run chart is **6 or more consecutive** points either all above or all below the median. Values that fall on the median do not add to nor break a shift. The shift and run rules require more than 10 points before they are applicable.

Rule 2: Trend



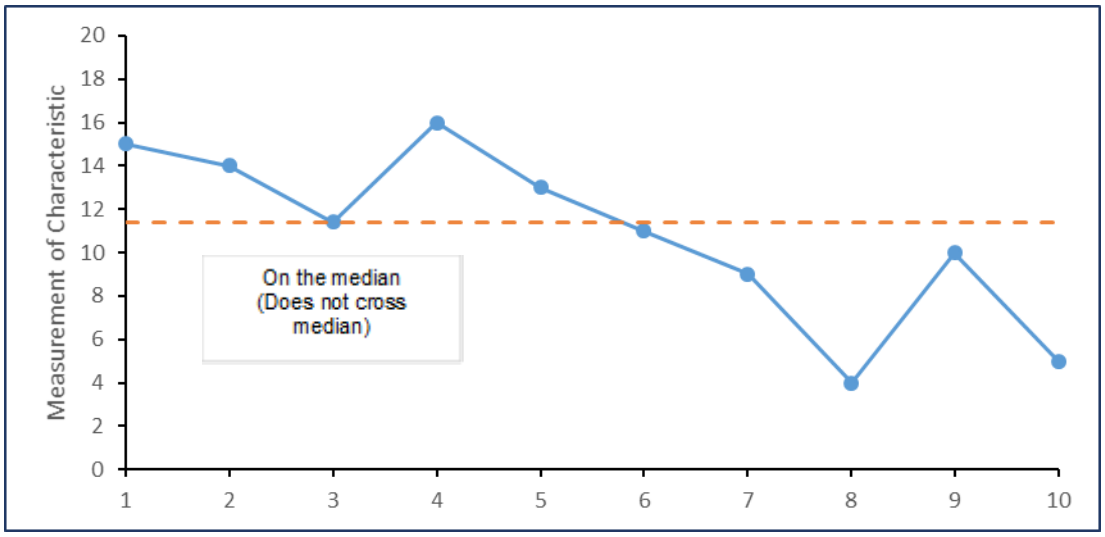
A **trend** on a run chart is **five or more consecutive** points all going up or all going down. If the value of two or more successive points are the same, ignore the successive points of equal value when counting. For example, the trends highlighted in the graph above both have successive points. The first trend has 6 points in total (ignoring point 7 as it is the same value as point 6). The second trend has 5 points in total (ignoring point 19 as it has an equal value to point 18).

Rule 3: Astronomical point



An astronomical point is an obviously blatantly different value which is clearly highly unusual. Be aware - every dataset will have a high point and a low point. This does not make them astronomical.

Rule 4: Runs



Count the number of runs and **always add one extra** – this is the number of times the line crosses the median. Refer to the runs table (Table 1 below): If the number of runs falls **within** the range between the lower and upper limit – this is random variation. If the number of runs falls **outside** the range between the lower and upper limit – this is non-random variation.

Table 1: Runs table

Total number of data points on the chart that do not fall on the median	Lower limit for the number of runs (< than this number is 'too few')	Upper limit for the number of runs (> than this number is 'too many')
10	3	9
11	3	10
12	3	11
13	4	11
14	4	12
15	5	12
16	5	13
17	5	13
18	6	14
19	6	15
20	6	16
21	7	16
22	7	17
23	7	17
24	8	18
25	8	18
26	9	19
27	10	19
28	10	20
29	10	20
30	11	21
31	11	22
32	11	23
33	12	23
34	12	24
35	12	24
36	13	25
37	13	25
38	14	26
39	14	26
40	15	27

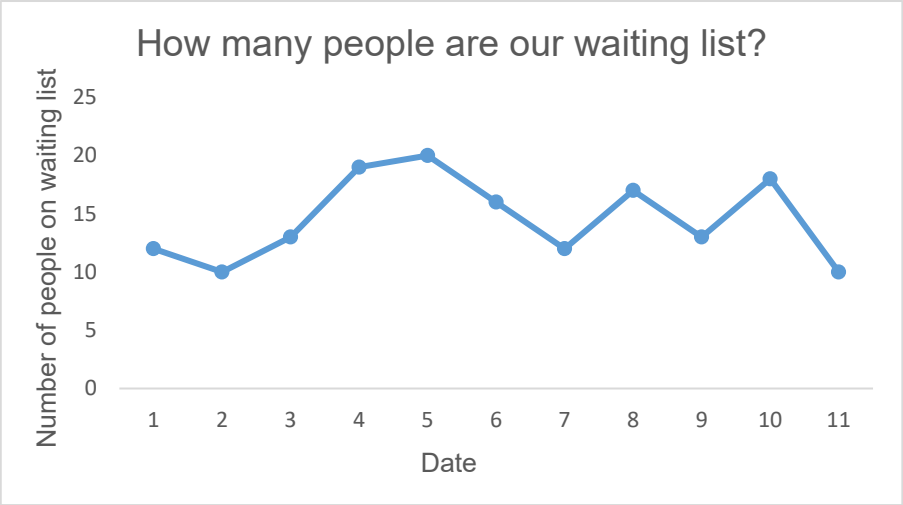
You may need to recalculate the median

Having detected a signal of improvement e.g. a shift or too few runs following a test of change, you may decide to recalculate your median. You may wish to recalculate the median to understand how much the improvement has affected your process. In this case, you will calculate a new median based only on data in the improved process. Therefore, the starting point for the recalculated median will be dependent on which signal of improvement was identified (i.e. where a new stable process has formed). If it was a shift, the starting point would be the first point of the shift. If it was a trend, the starting point would be after the trend.

Appendix 1:

You may wish to work out the median by hand:

Diagram 3

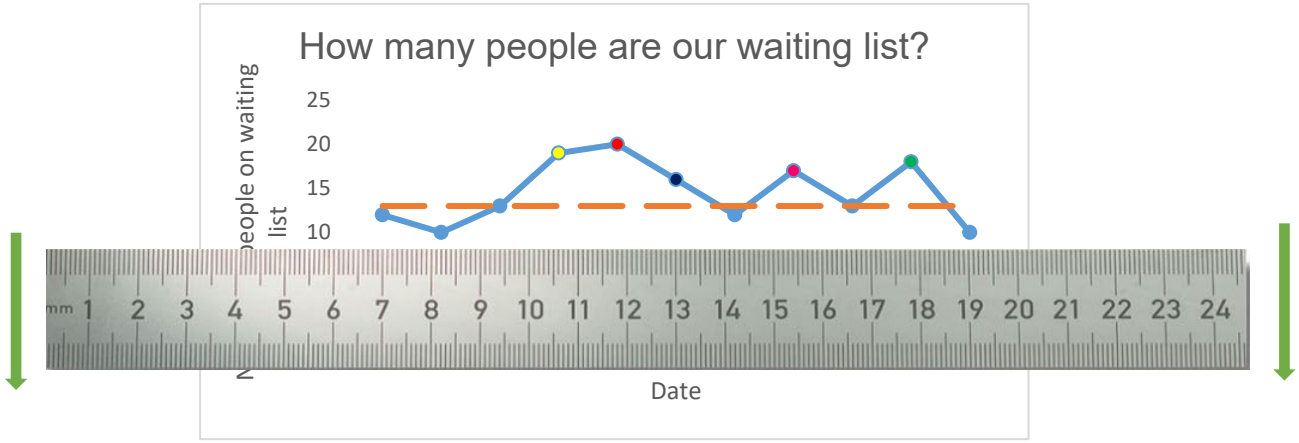


1. The above run chart has 11 data points, due to 11 days of data being collected.

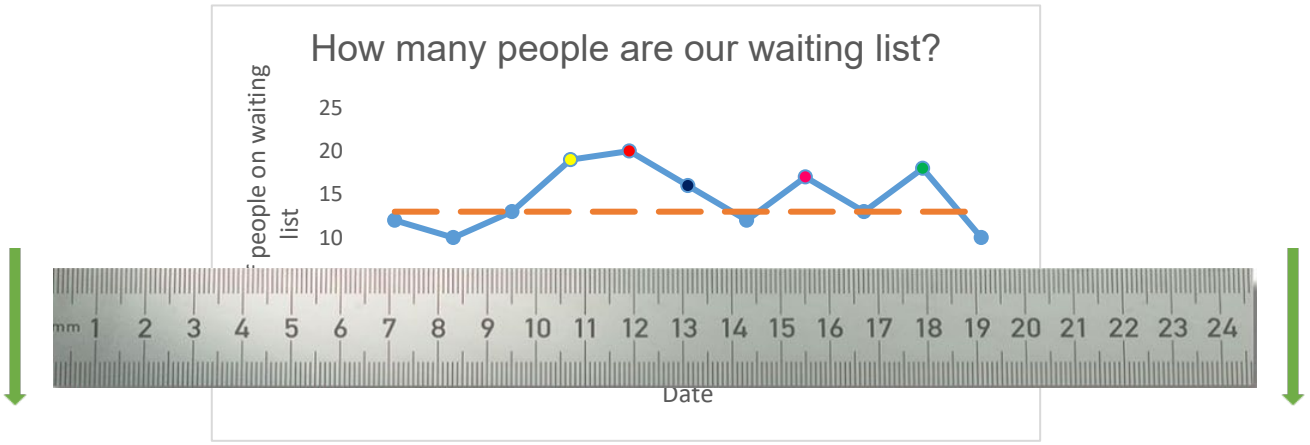
   To find the median position use the formula: **(n + 1) ÷2** *(n= number of data points).*

   Diagram 2: **(11+1) ÷ 2 = 6**

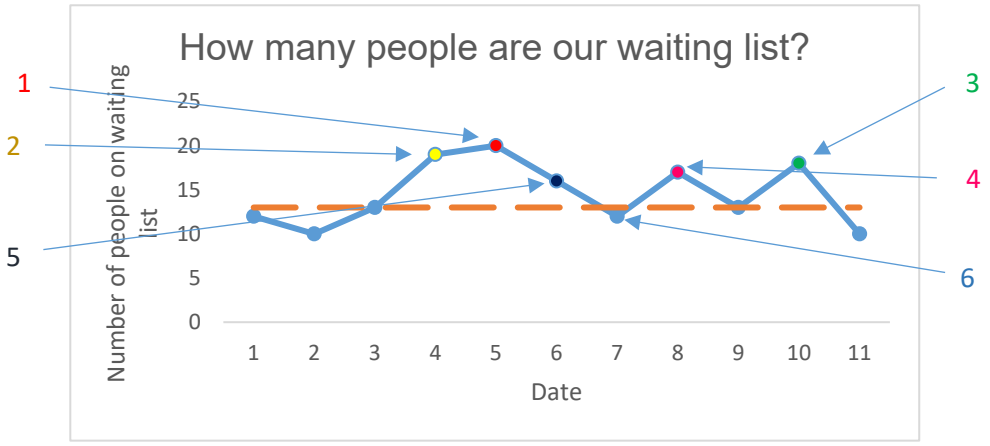
2. Place your ruler horizontally across the chart you have drawn.
3. Start at the data point with the highest value, in this case 20.



4. Sliding the ruler down the chart vertically and counting each data point in descending order will you get to data point six.



5. Having slid the ruler down the chart and counting the points, you will have got to your sixth data point:



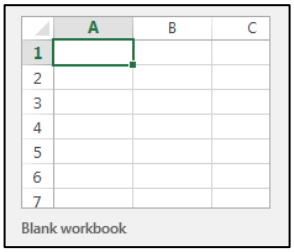
6. This is your **median value** and you need to draw the horizontal line across the graph at this point, so that it intersects at the y-axis.
7. You can confirm the point by placing your data in rank order and finding the middle number.
8. If you had 25 data points, for example, this would work out to be (25 + 1) ÷2 = 13. The median line lives at the data position 13. If you had an even number of data points, e.g. 24, you would not get a whole number to place the median line onto. The median line would fall at 12.5, so you would draw the line between data points 12 & 13.

Appendix 2: Run Chart by Excel

How to create a Run Chart in Excel

Open Excel and start a new workbook

1. Open Microsoft Excel
2. Create a blank workbook
3. You should see a blank worksheet with grid lines.



Start inputting your data

1. Starting in box A1 (top left), enter headings for the type of information you will enter into your Run chart. In this example, we will use the headings **Date, Measure** and **Median**

	A	B	C	D
1	Date	Measure	Median	
2				
3				
4				
5				
6				
7				

2. Next, enter some data into the columns in your table

	A	B	C	D
1	Date	Measure	Median	
2	10/01/2019			
3	11/01/2019			
4	12/01/2019			
5	13/01/2019			
6				
7				

3. For column A, use dates that correspond with your data collection intervals.

4. In column B, you need to enter the baseline data that correspond to the date they were collected in column A. There should be between 10-12 data points:

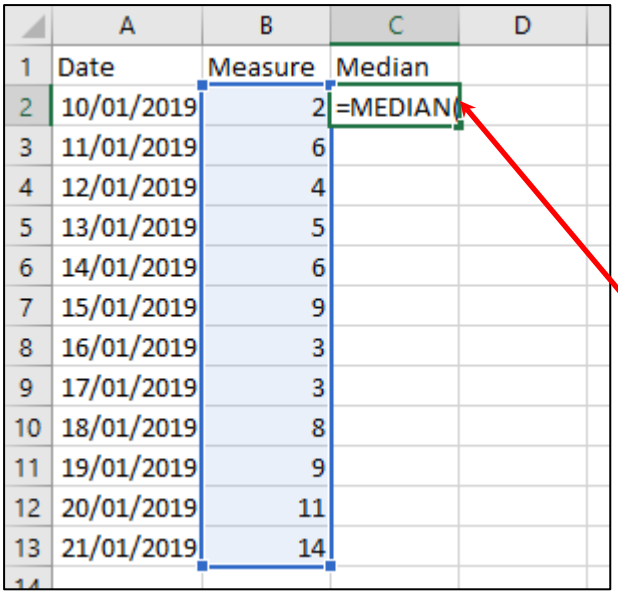
	A	B	C	D
1	Date	Measure	Median	
2	10/01/2019	2		
3	11/01/2019	6		
4	12/01/2019	4		
5	13/01/2019	5		
6	14/01/2019	6		
7	15/01/2019	9		
8	16/01/2019	3		
9	17/01/2019	3		
10	18/01/2019	8		
11	19/01/2019	9		
12	20/01/2019	11		
13	21/01/2019	14		

Calculate your median

5. In cell C2 type:

   =**MEDIAN(**$*(type in the column of the data)*$*(type in the row number of the start of the data)*:$*(type in the column of the data)*$*(type in the row number of the end of the data)*)

6. This will allow you to choose the group of numbers to be included in your median calculations, which will be included in the brackets (). You will use the median function to create a median line or recalculate the median for a Run chart.



	A	B	C	D
1	Date	Measure	Median	
2	10/01/2019	2	=MEDIAN(	
3	11/01/2019	6		
4	12/01/2019	4		
5	13/01/2019	5		
6	14/01/2019	6		
7	15/01/2019	9		
8	16/01/2019	3		
9	17/01/2019	3		
10	18/01/2019	8		
11	19/01/2019	9		
12	20/01/2019	11		
13	21/01/2019	14		

To calculate the median

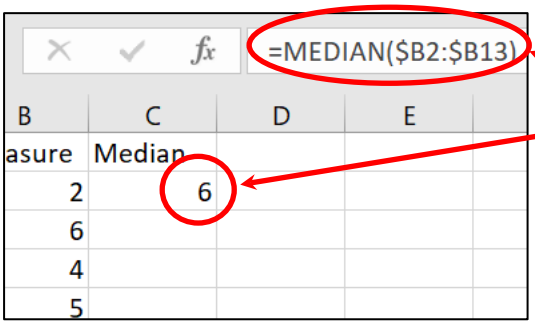
For this example, we use the formula

=MEDIAN($B$2:$B$13)

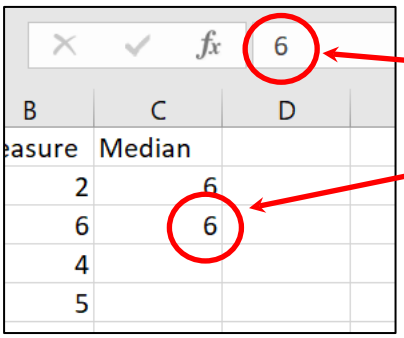
Type this in as below:

=MEDIAN($***(type in the column of the data)***$*(type in the row number of the start of the data)***:$***(type in the column of the data)***$***(type in the row number of the end of the data)***)**

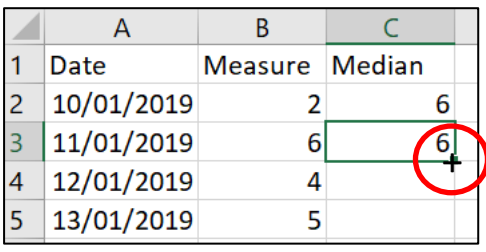
7. Next, we need to fill the other cells in the **Median** column with this calculation. To do this, move your mouse pointer to the bottom-right corner of the median cell. Wait until it turns into a '**+**' symbol. Click and hold your left mouse button and drag the box down next to the bottom row of your data.



If you click on cell C2 you will see the MEDIAN sum formula above.

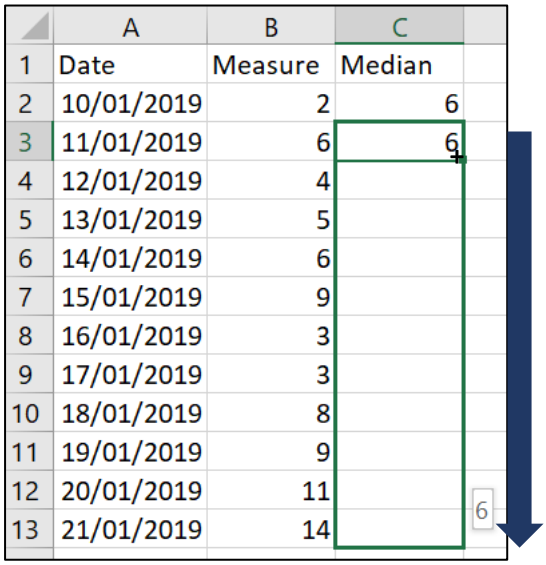


In the next row down in cell C3, type in the same number as in the cell above (the Median). This will show above as a number and not a formula.



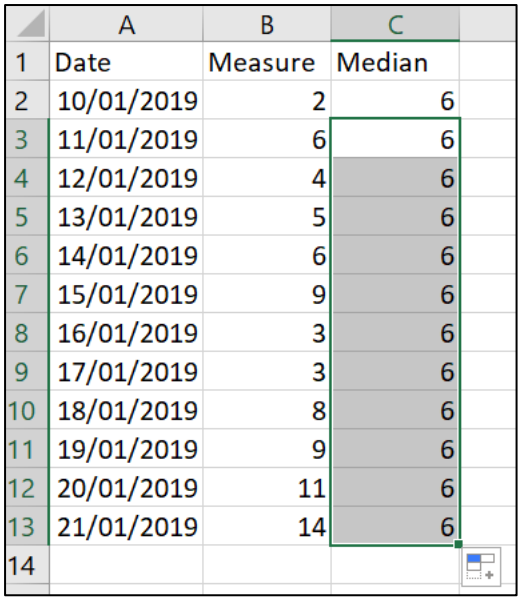
	A	B	C
1	Date	Measure	Median
2	10/01/2019	2	6
3	11/01/2019	6	6
4	12/01/2019	4	
5	13/01/2019	5	

Move the mouse to the bottom-right corner until you see the '**+**' appear.



	A	B	C
1	Date	Measure	Median
2	10/01/2019	2	6
3	11/01/2019	6	6
4	12/01/2019	4	
5	13/01/2019	5	
6	14/01/2019	6	
7	15/01/2019	9	
8	16/01/2019	3	
9	17/01/2019	3	
10	18/01/2019	8	
11	19/01/2019	9	
12	20/01/2019	11	
13	21/01/2019	14	

Then click and hold and move the mouse down to the bottom of your data.

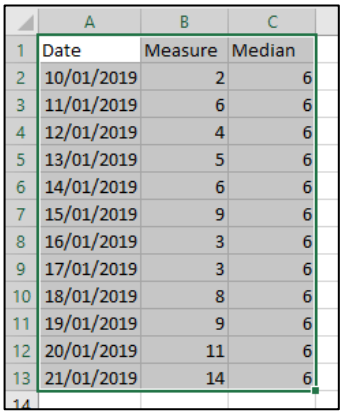


	A	B	C
1	Date	Measure	Median
2	10/01/2019	2	6
3	11/01/2019	6	6
4	12/01/2019	4	6
5	13/01/2019	5	6
6	14/01/2019	6	6
7	15/01/2019	9	6
8	16/01/2019	3	6
9	17/01/2019	3	6
10	18/01/2019	8	6
11	19/01/2019	9	6
12	20/01/2019	11	6
13	21/01/2019	14	6
14			

Release the mouse button & the median will fill down to the bottom.

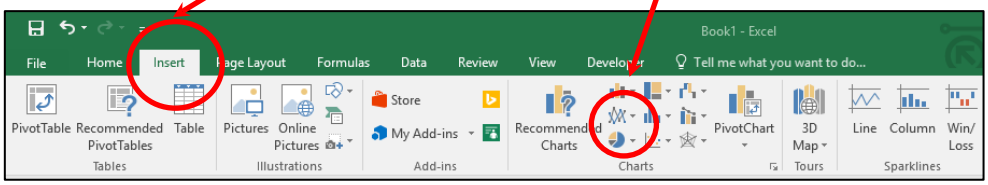
Create your Run chart in Excel

8. Now that you've entered all the data, it is time to create the Run chart itself. First, highlight all of your data (including headings).

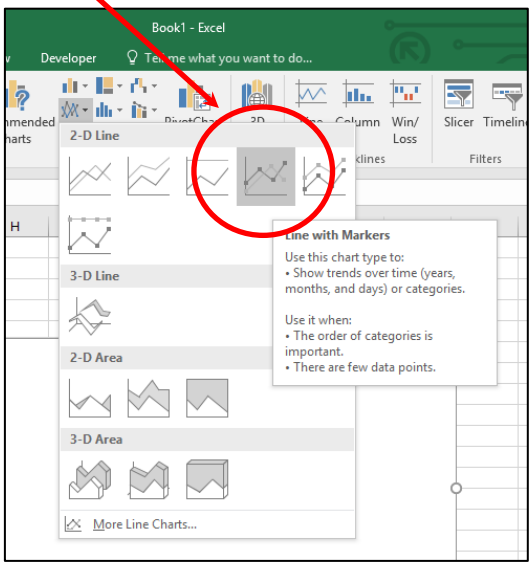


	A	B	C
1	Date	Measure	Median
2	10/01/2019	2	6
3	11/01/2019	6	6
4	12/01/2019	4	6
5	13/01/2019	5	6
6	14/01/2019	6	6
7	15/01/2019	9	6
8	16/01/2019	3	6
9	17/01/2019	3	6
10	18/01/2019	8	6
11	19/01/2019	9	6
12	20/01/2019	11	6
13	21/01/2019	14	6
14			

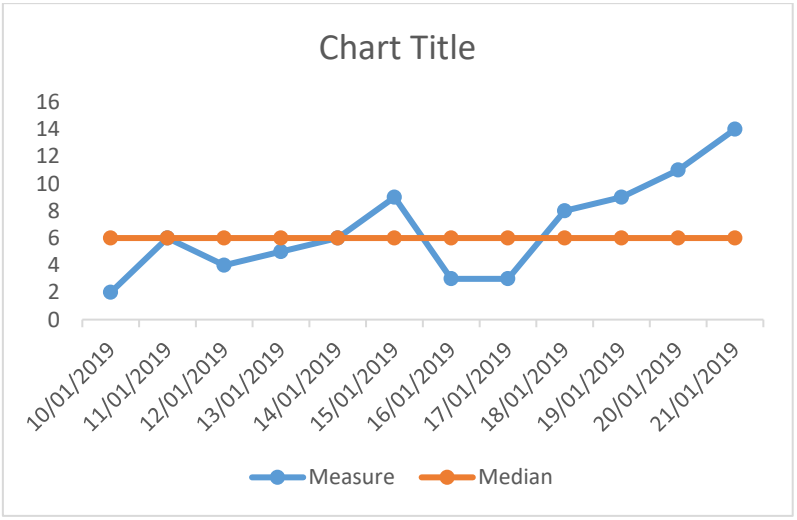
9. Next, go to the **Insert** menu and select the **Line Chart** option. 



10. Then, select **Line with Markers**.



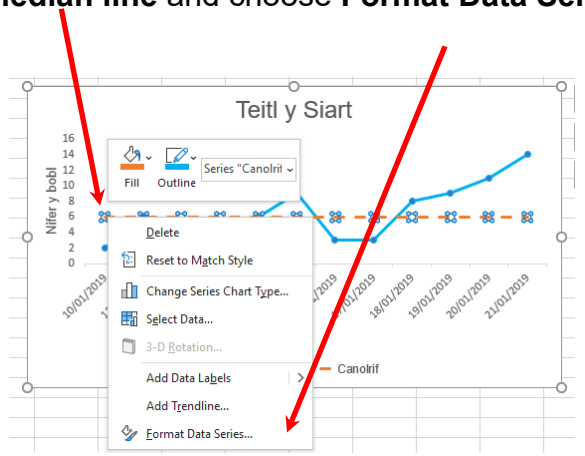
11. You should now have a chart that looks like this.



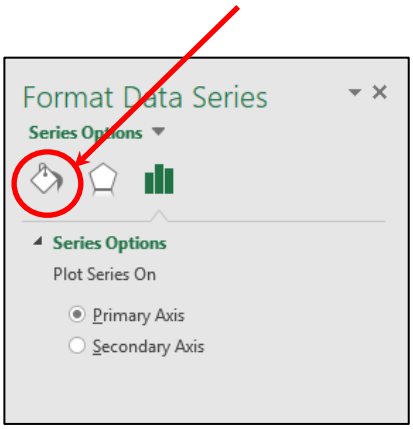
Formatting and labelling the chart in Excel

The median line

1. Right-click on the **median line** and choose **Format Data Series** from the menu that appears.

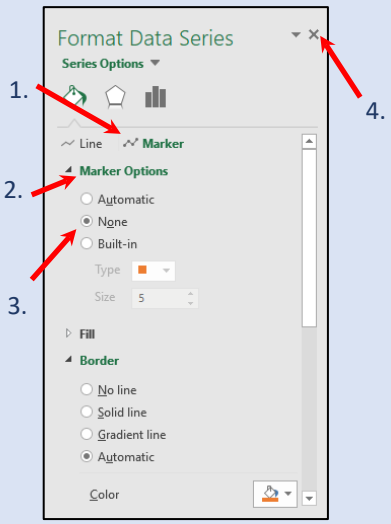


2. On the window that pops up, click on the paint pot.



To remove the data point markers from the median line

1. Click on **Marker**
2. Select **Marker Options**
3. Select the **None** radio button

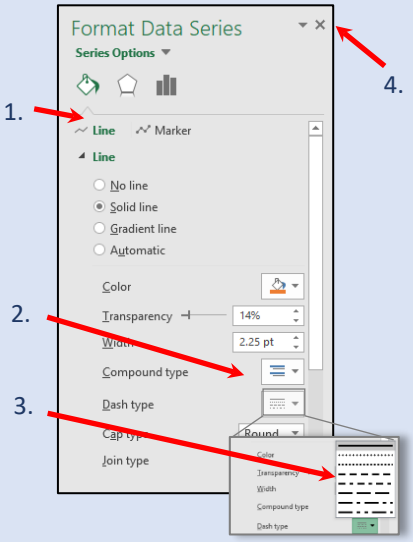


4. Close the **Format Data Series** window.

You have now removed the markers from your median line.

To change the median line from a solid line to a dashed line

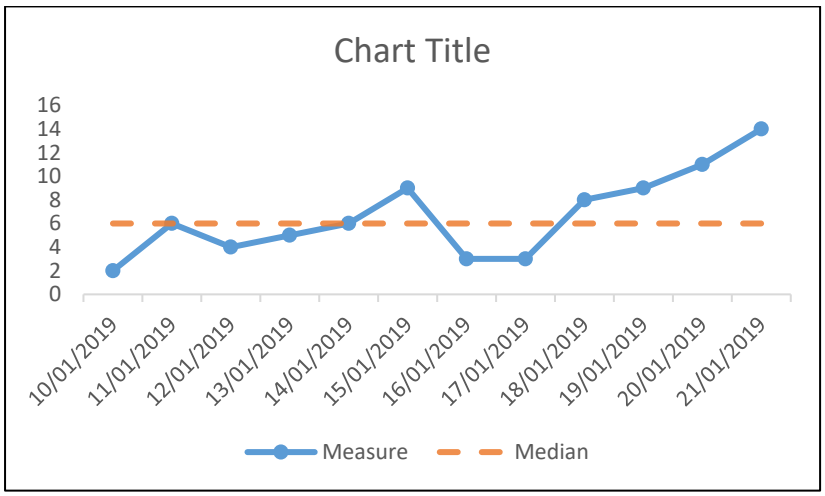
1. Click on **Line**
2. Select the drop down next to **Dash Type**



3. Select the type of dashed line to use:
4. Close the **Format Data Series** window.

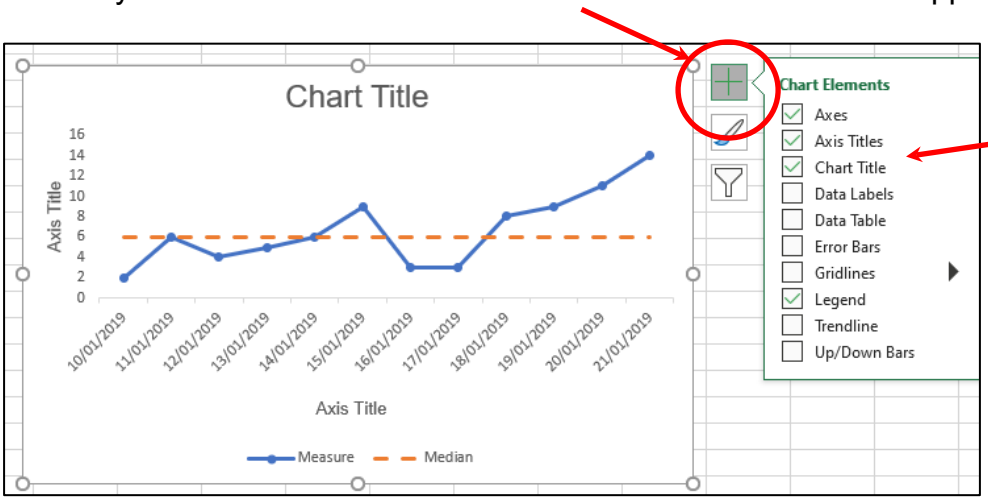
You have now changed the line from a solid line to a dashed line.

Your chart should now look like this:



Adding labels to the chart

3. Click anywhere on the chart and then select the '**+**' button to the upper right.



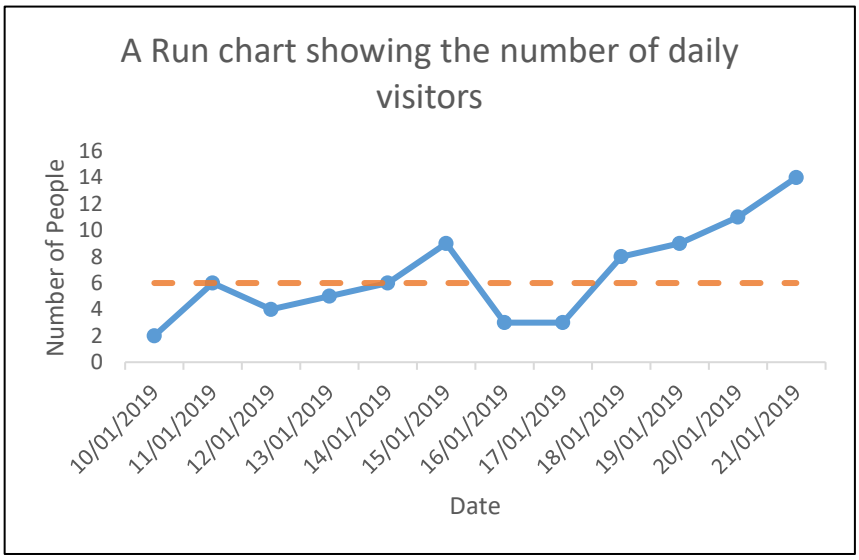
Tick ☑ **Axes**, ☑ **Axis Titles**, ☑ **Chart Title.**

You can also select **Gridlines** if you wish.

Untick the other boxes if they are already ticked (i.e. **Legend**).

4. In the pop-up that appears, select (tick the boxes) for ☑ **Axes**, ☑ **Axis Titles**, and ☑ **Chart Title**. You can also select **Gridlines** to make the data easier to read. The other options should be de-selected (un-ticked boxes). This has been done in the example above.

5. You can now edit the labels by clicking on the chart and then clicking on the relevant text. Your Run chart should now look like this.



Do you need to recalculate the median?

1. Having detected a signal of improvement through the use of S.T.A.R. (pages.6-9) e.g. a shift or too few runs following a test of change, you may decide to recalculate your median.

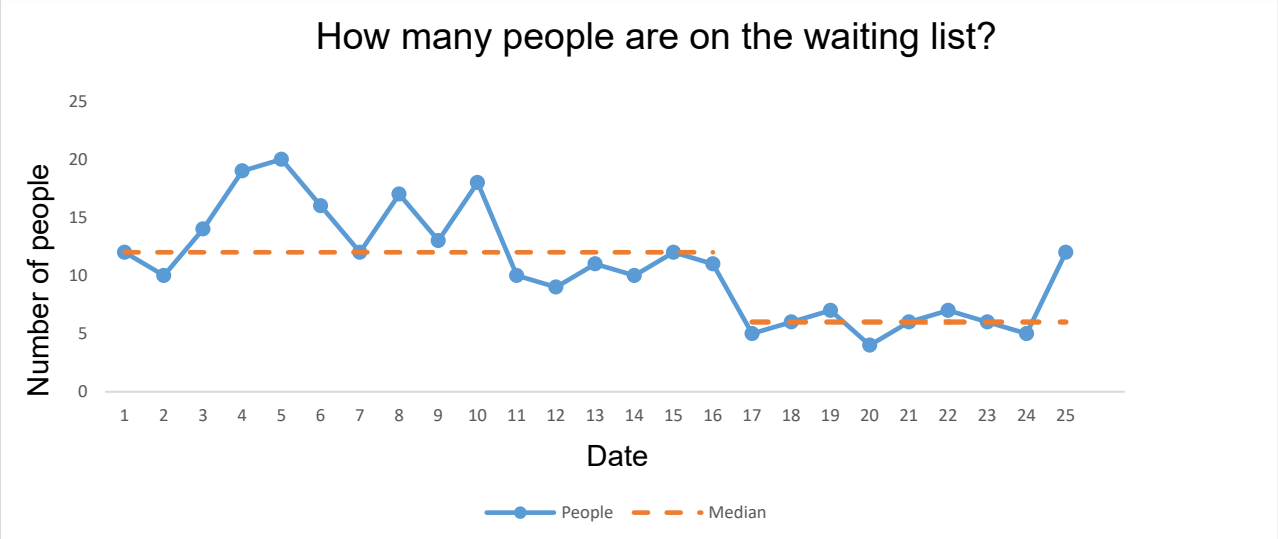
2. Having frozen and extended the median line, you need to look at your Run chart and look for signals of improvement.

3. If the signals of improvement are evident, you can now recalculate your median. Follow the process you used earlier with the median formula. The formula now needs to be placed into your Excel document from the starting point of when you noted the shift and continued through to the end.

Type the new median into an additional column.

	A	B	C	D
1		Measure	Median	New Median
2	1	12	12	
3	2	10	12	
4	3	13	12	
5	4	19	12	
6	5	20	12	
7	6	16	12	
8	7	12	12	
9	8	17	12	
10	9	13	12	
11	10	18	12	
12	11	10	12	
13	12	9	12	
14	13	11	12	
15	14	10	12	
16	15	12	12	
17	16	11	12	
18	17	5		6
19	18	6		6
20	19	7		6
21	20	4		6
22	21	6		6
23	22	7		6
24	23	6		6
25	24	5		6
26	25	12		6

This will alter your median line.



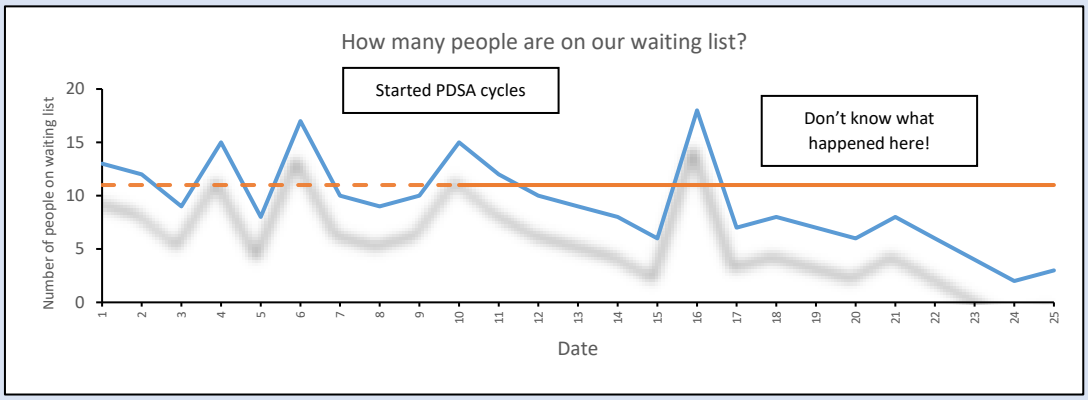
(Lloyd, 2017)

Finally, please do not

Microsoft Excel has a lot of options to add visual effects to charts, however please bear in mind that the most important thing is that the Run chart is **clear and easy to read.**

So please don't…

- Distort what the data have to say
- Cover data points with labels
- Mask important changes
- Use three-dimensional charts or effects which make the chart hard to read



The above chart has had effects applied and labels added which are obscuring the data; it would not be suitable for an improvement project.

What next?

The run chart has simplicity and versatility in letting us learn by the data. You can now evaluate the success of the improvement efforts in an objective way.

Helpful tips

Please remember a run chart cannot determine whether a process is stable.

Run charts are designed to detect early improvement or degradation in a process over time.

Additional resources

If you would like to learn more about making improvement to your workplace take a look at our website for what we offer you https://phw.nhs.wales/services-and-teams/improvement-cymru/improvement-cymru-academy/ or email us improvementcymruacademy@wales.nhs.uk to find about the improvement courses we can offer.

References

Ihi.org. (2019). *IHI resource Page*. [Online] Available at: http://www.ihi.org/resources/Pages/Tools/RunChart.aspx [Accessed 12 Feb. 2019].

Improvement.nhs.uk. (2019) *Run charts NHS Improvement*. [Online] Available at: https://improvement.nhs.uk/resources/run-charts/ [Accessed 6 May 2019].

Lloyd, R. (2017). *Quality health care. A guide to developing and using indicators*. Burlington, Massachusetts, United States. Jones and Bartlett Publishers, Inc.; 2nd Revised edition.

NHS East London NHS Foundation Trust (2012). *Run Charts*. [online] https://qi.elft.nhs.uk/resource/run-charts/ [Accessed 27 October 2021].

Perla, R, J., Provost, L, P. and Murray, S, K. (2011). The run chart: a simple analytical tool for learning from variation in healthcare processes. *BMJ Quality & Safety,* 20, pp. 46-51.

Provost.L. & Murray.S. (2011). *The Health Care Data Guide: Learning from Data for Improvement*. USA. John Wiley & Sons.