

Some information on Statistical Process Control (SPC) c charts that may be useful for clinical teams

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Changes since the July 2009 Version	
Throughout	Date and version number changed
Throughout	Infection control team to infection prevention and control team (IPCT)
P10 4 th bullet	Minor changes to test

Some information on Statistical Process Control (SPC) c charts that may be useful for clinical teams

All the SPC charts in the document refer to 'c' type charts. C charts are useful charts which only use numerators, e.g. number of *C. difficile* isolates each month. They do not use denominators, e.g. patient days, number of persons at risk, as such they have limitations and they should only be used where the area of opportunity changes little, i.e. their use here assumes that total patient occupancy in any given ward remains relatively static per time period. Where this is not the case other types of charts can be used.

(All data presented are fictitious)

There are other ways of being out of statistical control for which examples have not been given - your ICT will advise

Statistical Process Control Charts (SPCs)

The number of new patients with MRSA or *C. difficile* thought to have been acquired in your unit (or ward) is being fed back monthly in the form of a statistical process chart (SPC). SPCs are the application of statistical theory to Quality Control. SPCs show data **chronologically** and describe the data as either natural variation or unnatural variation. **Natural variation** indicates that any change in the number of new cases from month-to-month is just part of the system, e.g. the time you come to work every morning probably varies by a few minutes around an average – it varies naturally. But if there was an accident on the road then the time taken to come to work would be significantly longer – this would be **unnatural variation** indicating that something in the system of bringing you to work has gone awry.

To produce the ward SPC charts, calculations are made from the ward/unit's historical acquisition data to produce 3 lines,

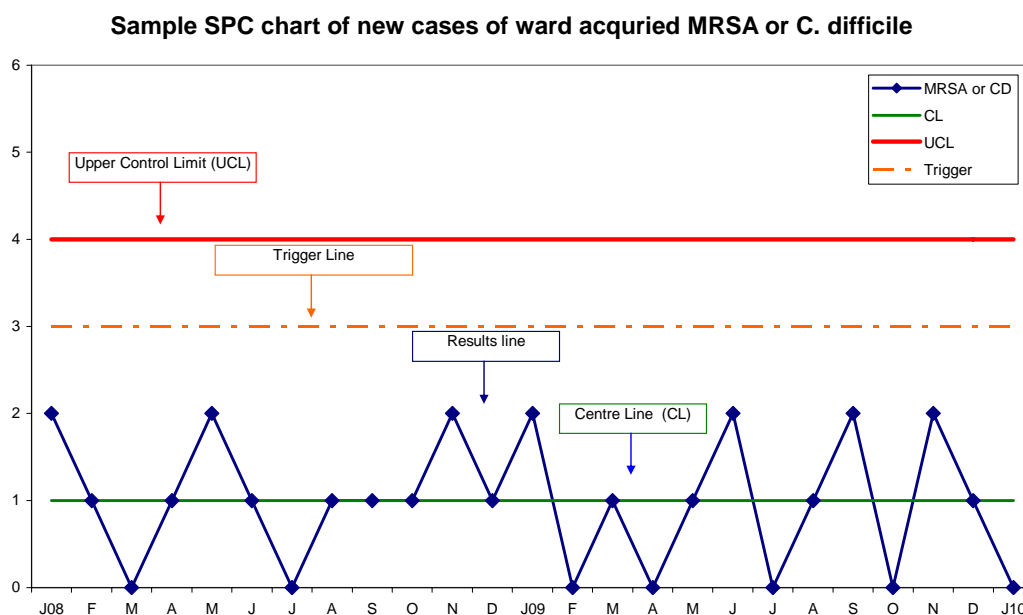
- the **Centre Line (CL)** is the average number of acquired cases per month;
- the **Trigger Line (Trigger)** a warning limit, results that reach or exceed the **Trigger** should be investigated for possible problems in infection control;
- the **Upper Control Limit (UCL)** it is the limit of natural variation all results should be below the **UCL** – and any result above is considered unnatural variation and out of statistical control.

The **UCL** is set at the mean (**CL**) plus 3 standard deviations of the mean. Any result above the **UCL** suggests that there are probably problems in one or more infection control systems. Provided all else remains unchanged, e.g. patient population size of the ward, results above the **UCL** indicate that something in infection control systems has/is probably going awry. There are other criteria for being out of statistical control, e.g. 8 results in a row above the **CL** or 8 results indicating an increasing trend. SPCs can detect **significant improvements** as well as deteriorations in infection control systems this would be indicated by for example 8 in a row below the **CL**.

Rationale: If infection control practices and antimicrobial prescribing is stable, and the environmental cleanliness level does not change, if there are sufficient staff who follow procedures correctly, then the number of new patients with acquired MRSA or *C. difficile* will be stable and fall within predicted limits, i.e. below the **UCL**. If the number of new cases rises above the **UCL** this suggests that the increase is statistically likely to be due to one or more special causes – something in any infection control system is awry, and investigations are required to look for and rectify problems.

For ease of reading, the **CL is coloured green**, the **Trigger or warning line is coloured amber** and the **UCL is coloured red**.

The **Upper Control Limit (UCL)** defines the limit of natural variation. Any result above the **UCL** indicates a statistically significant out of control process. A warning limit or **Trigger** is set at 2 standard deviations above the mean. **Triggers** are less sensitive and investigations are less likely to identify poor infection control systems – but investigations of **Triggers** can prevent outbreaks by detecting problems early. The chart below illustrates **the monthly number of new cases (blue)** and the three lines of the SPC the **UCL**, the **Trigger** and the **CL**.



How do you read an SPC?

To read an SPC – ask three questions

Does the **Centre Line (CL)** run through the centre of the results?

To be stable and in control the **CL** should run through the centre of the results

And, is the latest result below the **Trigger** and or the **UCL**?

To be in control the latest result must be below the **CL**

Is there evidence in the latest 5-8 results of:

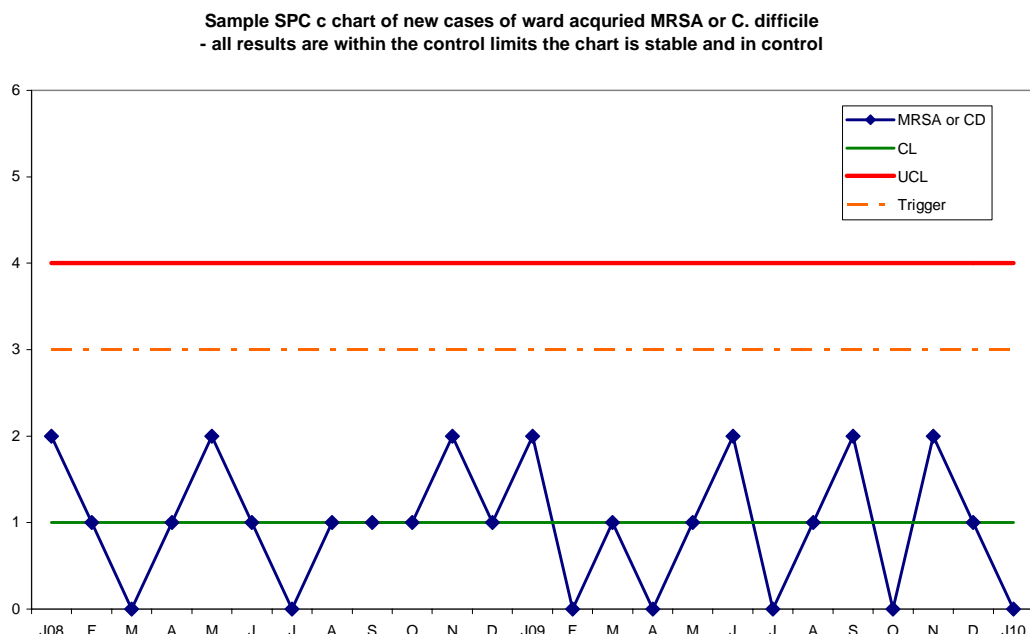
- The results being on one side of the **CL**
- A trend in one direction

To be in control the results should not be biased on one side.

The next few charts show some types of variation that can be seen in SPCs.

A SPC c chart which is showing natural variation, i.e. stable and in control infection control systems

Here is a chart with a table answering the questions on how to read it.

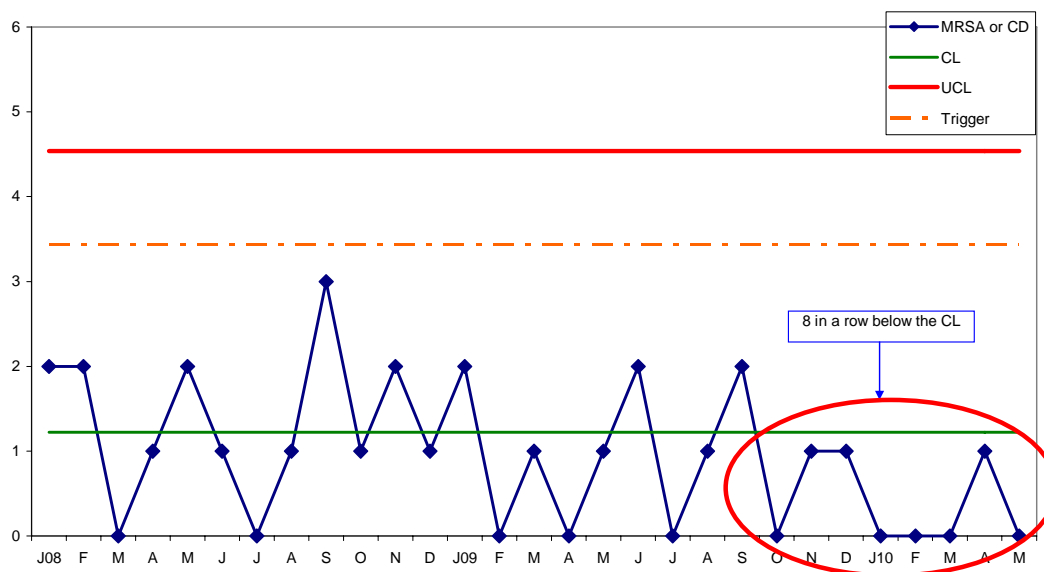


Does the Centre Line (CL) run through the centre of the results?	Yes, roughly half the results are above and half below the CL , indicating stability and control
Is the latest result below the UCL and the Trigger line?	Yes, the latest result is within the Trigger and UCL
What is the trend in the last few results?	The last 8 results indicate no change in variation, this chart is stable and in control.
NB Stable and in control does not mean optimal – it means no sign of improvement or deterioration in the systems	

A SPC c chart indicating unnatural variation - significant improvements in infection control

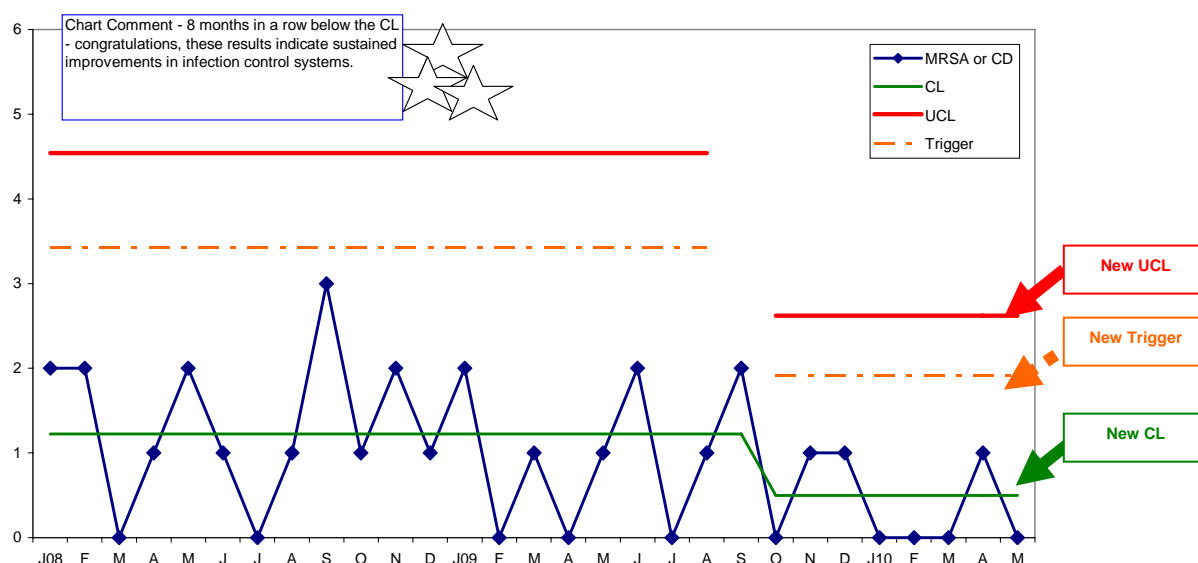
SPCs can indicate significant improvements as well as deteriorations in practice. In the chart below the number of new cases has consistently fallen below the **CL** – to be precise 8 times in a row. 8 results in a row, above or below the **CL** is thought to be unlikely to be due to chance. Something in infection control has changed. Note in this chart the **CL** no longer fits. It does not run through the centre. At this point an adjustment would be made to reduce the **CL**.

Sample SPC c chart of new cases of ward acquired MRSA or C. difficile showing 8 results in a row below the CL indicating that there has been a significant improvement in infection control systems



This is what the chart looks like with a lowered **CL**. (NB. Lowering the **CL** will as a consequence lower the **Trigger** and **UCL**).

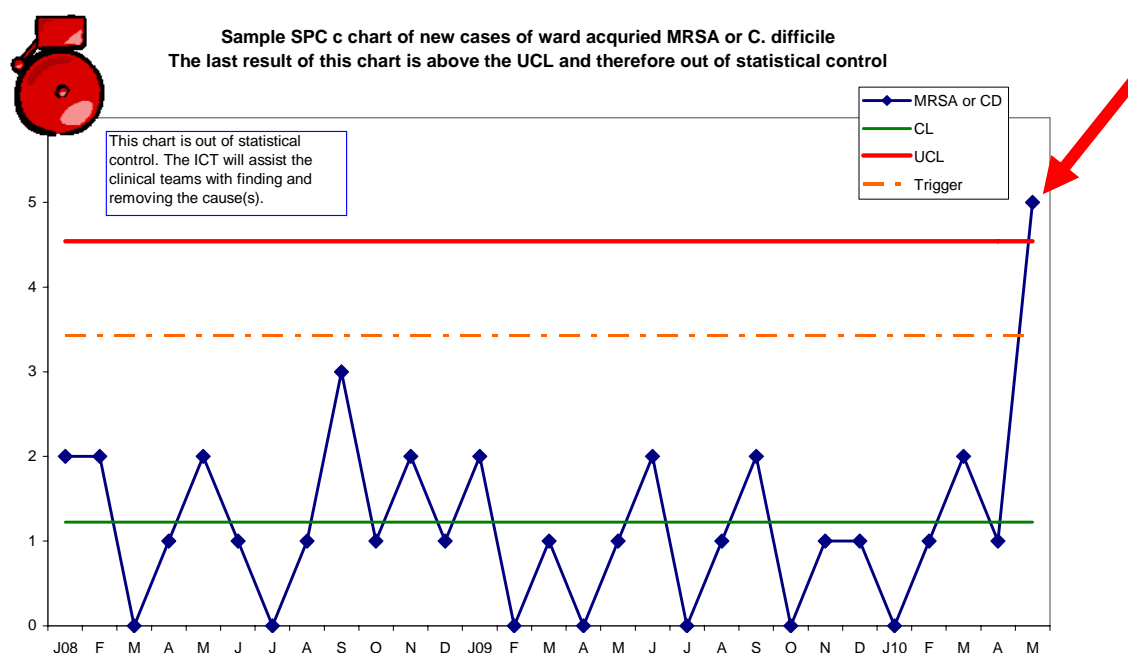
Sample SPC c chart of new cases of ward acquired MRSA or C. difficile - showing a lowered CL and consequently lowered UCL and trigger line



Lowering the **CL** would be accompanied by a “well done” as the results are indicating a sustained improvement in infection control. Note now the **CL** has been lowered it runs through the centre of the results again. The lowering of the **CL** is done retrospectively.

A SPC c chart showing unnatural variation it is out of statistical control identified by one result above the **UCL**

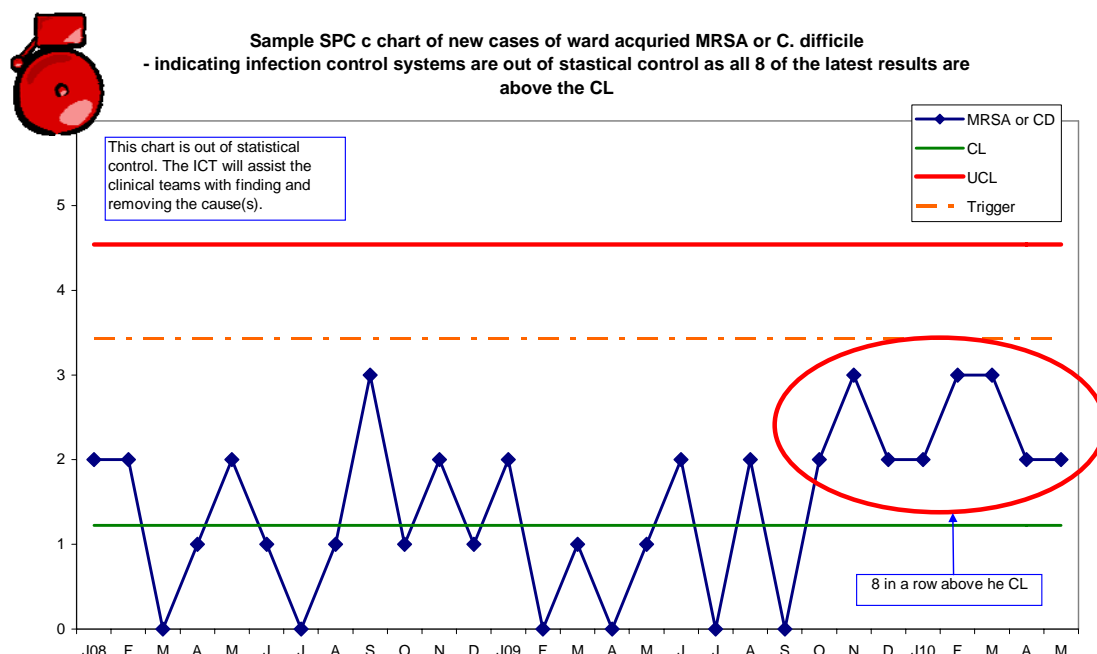
One result above the **Upper Control Limit (UCL)** indicates that there is an infection control problem!



The infection prevention and control team (IPCT) will assist the clinical teams with finding and rectifying the cause(s) when wards are out of statistical control.

Does the Centre Line (CL) run through the centre of the results?	Yes, roughly half the results are above and half below the CL
Is the latest result below the UCL and the Trigger line?	No. The latest result is above the UCL indicating infection control systems are out of statistical control
What is the trend in the last few results?	The trend is ok apart from this last result.
NB If the chart is out of statistical control this will be clearly indicated by the IPCT.	

SPC indicating unnatural variation it is out of statistical control identified by 8 results in a row being above the CL



The IPCT will assist the clinical teams with finding and rectifying the cause(s) when wards are out of statistical control.

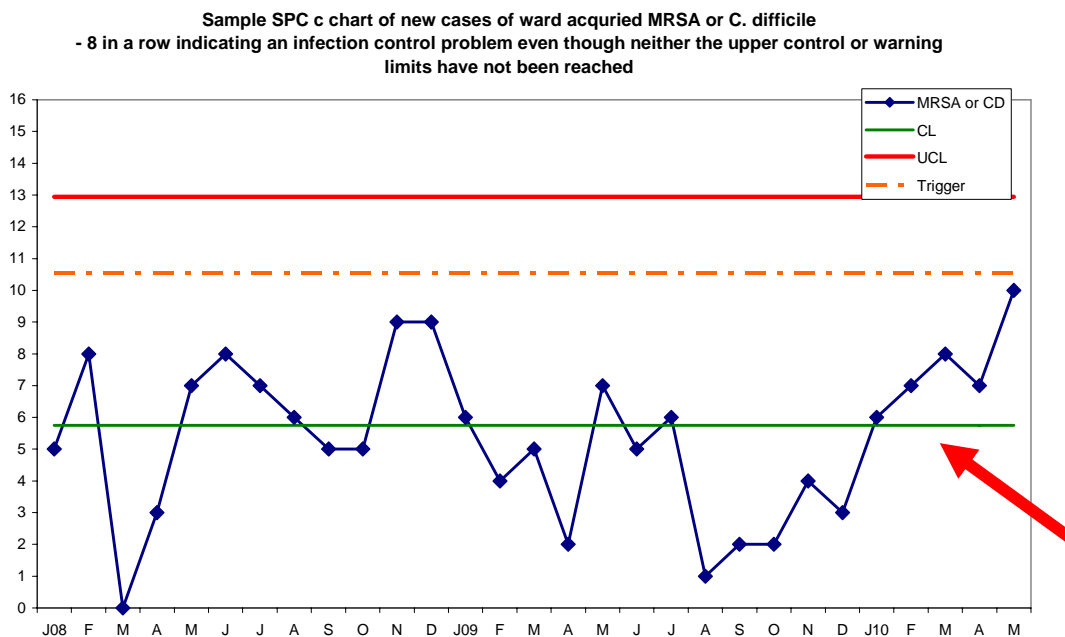
Does the Centre Line (CL) run through the centre of the results?	For most of the chart it does, but not for the last 8 results
Is the latest result below the UCL and the Trigger line?	Yes
What is the trend in the last few results?	All above the CL – this chart is out of statistical control
NB If the chart is out of statistical control this will be clearly indicated.	

Note also that the **CL** is not raised as with the chart on page 7. The IPCT will be very reluctant to raise a **CL**, indications for doing so are quite exceptional, e.g. change in the population of a ward. On the other hand indications for lowering the **CL** will be taken at the earliest opportunity.

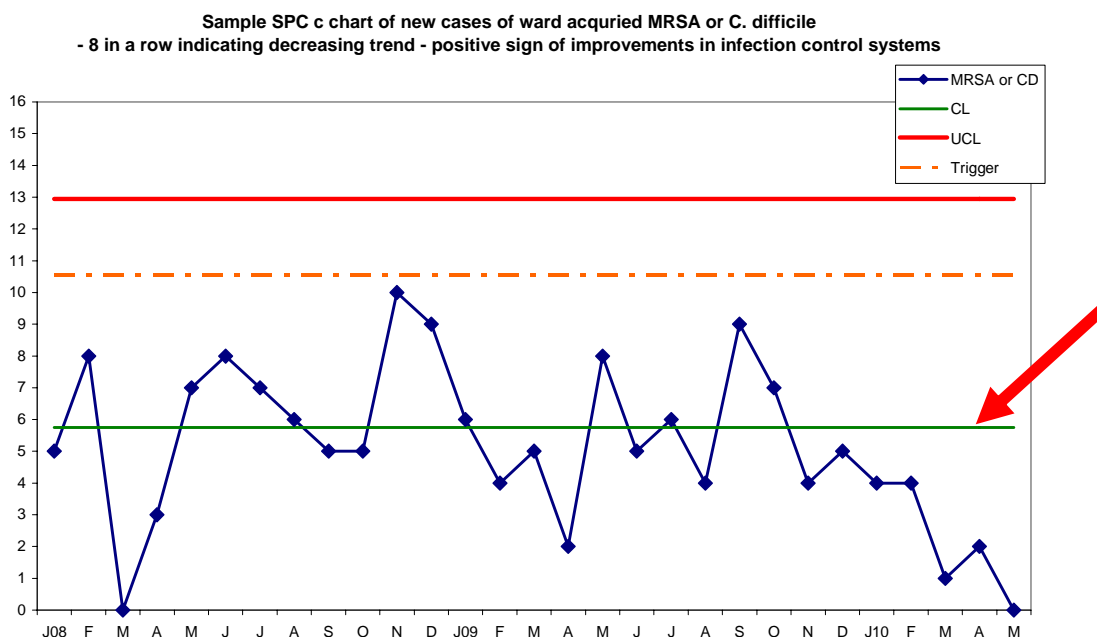
Charts showing unnatural variation – out of statistical control identified through trends in a single direction

One last indicator of out of control to look for is 8 in a row indicating an increasing or decreasing trend.

Here 8 results in a row are indicating an **increasing** trend. (Infection control problem).



Here 8 results in a row are indicating a **decreasing** trend. (Improved infection control).



Suggestions as to how you as a ward manager can use your chart to improve the infection control system in your area

- Put the chart in a prominent position and discuss the results of the chart with your team. Explain that the chart can be used to monitor infection control practices. Include discussions about the results at team meetings.
- Annotate the charts with process changes, tests of change, bundles commencing, etc.
- If the chart is positive – showing consecutive results below the CL give praise to your staff for achieving the positive results.
- If the chart is out of statistical control in a negative way, or a **Trigger** has been reached – identify possible causes and rectify them. Work with the IPCT to identify possible causes, e.g.
 - Have there been sufficient staff on duty?
 - Have healthcare workers in general been following good infection control practices?
 - Have patients who require isolation been isolated well?
 - Are decolonising solutions being used as required, (e.g. for patients with MRSA)?
 - Is hand hygiene good?
 - Is the ward visibly clean and uncluttered?
 - Is in use equipment and ready-for-next use equipment visibly clean?
 - Ask the cleanliness champion for opinions and suggestions.
 - Ask the AMT to find out if the antimicrobial prescribing is optimal?
 - Consider using a Trigger Tool (Generic or CDI).
 - Consider using a specific bundle to improve a system.
- Make a plan of action to get back in control.

Whatever the average (**CL**) on your ward of acquired MRSA or *C. difficile* isolates, as this is measured over time, you have in effect got systems designed to get this number, e.g. if the average is 2, you have a system designed to get 2 MRSAs or *C. difficile* isolates a month. If you and your team want to reduce the number of patients with ward acquired MRSAs or *C. difficile* isolates, then they will have to change the systems of infection control. These improvements will need to be sustained. If you and your team do improve infection control practices then the chart will be able to detect them by means of a reducing incidence.

If you would like help to do this contact an infection control nurse.

Some Additional Information

To help you understand and interpret the charts a comment is added. Explanations of these comments are shown in the table below

Chart comments	Explanation
In control	Results are within the control limits but subject to wide variation.
Stable and in control.	Results are within the control limits and subject to natural variation. NB Stable and in control does not mean optimal – it means predictable.
Out of statistical control.	Something in the infection control systems has or is going wrong.
5,6,7 in a row	As 8 results in a row above, below or in an increasing trend indicates an out of statistical control process, the comments section will give warnings from 5 months on indicating the number of results that are above or below the CL .
Lowered CL	A CL will be lowered when there have been 8 or more results in a row below the CL , indicating significant sustained improvement in infection control.

Statistical Process Control Charts

The **UCL** and LCL (lower control limit) should be symmetrical around the **CL**, however when the **CL** is <9, the LCL is a negative number. If the LCL is negative it can be either rounded to zero or more logically removed.