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Making data count

#plotthedots

NHS
Improvement

collaboration   trust   respect   innovation   courage   compassion

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Foreword

During my NHS career I have learnt a lot about how we can best use data to assist our decision-making. Many of us will have relied on comparing two points – perhaps performance this month and last, or this year and last. But the problem with looking at two points of data is that it tells you nothing about trends and how much the data varies naturally.

Statistical process control (SPC) is an analytical technique – underpinned by science and statistics – that plots data over time. It helps us understand variation and in so doing guides us to take the most appropriate action.

Adam Sewell-Jones
Executive Director of Improvement,
NHS Improvement

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In his 2004 book *Escape fire: Designs for the future of healthcare,* Dr Donald Berwick states that...

"Plotting measurements over time turns out, in my view, to be one of the most powerful things we have for systemic learning."

SPC is widely used in the NHS to understand whether change results in improvement and in industry for quality control. I would argue that SPC is one approach that we should increasingly use when considering our performance and operational data. These are the reasons why:

- SPC alerts us to a situation that may be deteriorating

- SPC shows us if a situation is improving

- SPC shows us how capable a system is of delivering a standard or target

- SPC shows us if a process that we depend on is reliable and in control.

You will learn from this guide that there is strong evidence that better decisions are made when using SPC rather than 'simple' techniques such as the popular RAG approach. This underpins the commitment in **Developing People - Improving Care** to ensure that the way in which we use data gives an adequate understanding of an organisation's trajectory of performance. 'Green' can provide false assurance and mask deteriorating performance. The opposite may be true when seeing 'red'.

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You may have heard that SPC is complicated – the practical application of it is not. For many of you, understanding how to react to data is the most important thing, not the detail of the statistical rules that underpin SPC.

You may find that messages from this guide challenge your thinking and that of your colleagues. I encourage you to keep an open mind. The benefit you will gain from adopting our approach will be significant.

I hope this guide will encourage many more people at all levels in the NHS – from ward to board – to make better use of data and to make data count.

How the presentation of data influences our decision making

Adam Sewell-Jones talks about how different presentations of data can lead to different conversations, conclusions and actions. He explains why it is important that NHS Boards in particular choose the best format of data presentation to inform their decision-making.

Welcome to *Making data count*, a guide that is designed to support people working in the NHS to make the best use of their data to inform judgements and decisions for action.

What does this guide do and who is it for?

What this document is…

… an interactive guide for people responsible for analysing, interpreting and presenting data to others (known as analysts) and decision-makers (managers and clinicians) who need data to answer questions.

It describes why you should be presenting and using data more effectively and how to do it.

It provides a toolkit for those wanting to make better judgements and decisions in healthcare. Case studies and exercises illustrate the different perspectives that clinicians, managers and analysts bring and show how closer working between these groups can add great value. This document contains links to useful videos, resources, tools and practical exercises.

For those looking for further opportunities to collaborate and learn, we provide details of how to connect with the growing community who are doing just this.

How to use this document

The guide can be accessed in two ways.

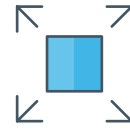You can 'dip in' – using the icons to identify the content you want to access.

Web link	Video link	Expand	Exercises	Scenarios	Pledge

Or you can work your way through the guide – choosing the path written for those with an analytical background/role or the one for those who instead have a decision-making role. Or – if you can find the time – why not read the whole guide? In the last section, we include a range of activities to be done jointly by analysts and those of you needing to use data to make decisions.

We hope you enjoy this guide; it owes a debt to extensive work by many previous NHS organisations and includes just a few examples of the exceptional work going on in the NHS. We hope it changes the way you look at data and incentivises you to ensure that connections are made between clinicians, managers and analysts to make better use of your organisation's data.

Share your experiences of making the best use of your data to support better judgement and decisions for action via Twitter using **#plotthedots**
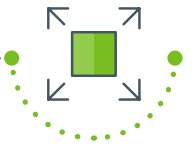
Nuts and bolts: making the case for better use of data

Before we get into the detail, we'd like you to gather together some colleagues and do an exercise that illustrates how the way data is presented can influence your decisions and actions.

Print out report 1 or gather around the screen and discuss this presentation of data.

Performance table	Target	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017	Aug 2017
Metric 1	50	100	100	83	100	100	100	100	67
Metric 2	75	86	84	82	82	75	80	81	81
Metric 3	95	100	99	100	100	100	100	100	100
Metric 4	50	57	57	54	56	53	52	55	55

- What do you think about this report?
- Is it a useful presentation of data?
- What kind of conversation did you have?

- What did it tell you?
- Importantly, what action would you take as a result of looking at it?

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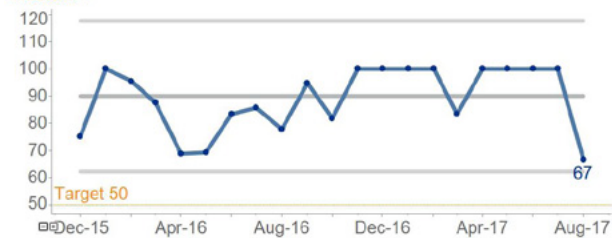
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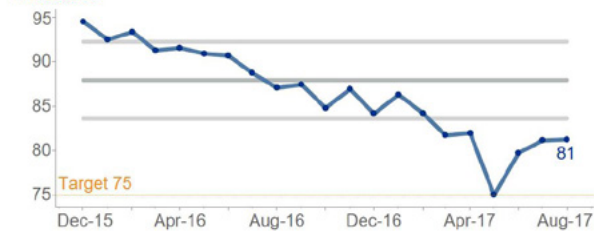
Okay, now let's move on to report 2… Again, print this out or gather around the screen.

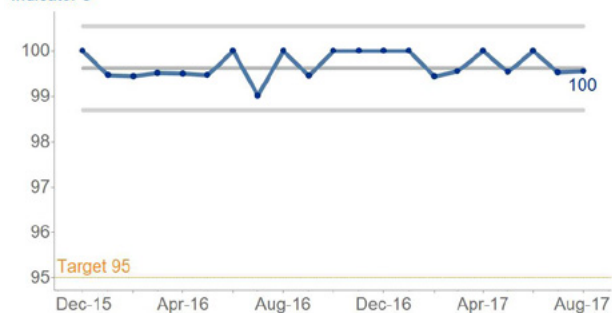Key performance indicator dashboard

- What do you think about this report?
- Is it a useful presentation of data?
- What kind of conversation did you have?

- What did it tell you?
- Importantly, what action would you take as a result of looking at it?

Now take a few minutes to discuss these different presentations.

- Do you often see data presented in either style?

- Which did you like/dislike?

- Which was the most useful?

- Which prompted the most useful conversation with your colleagues?

Report 1

- Did this feel like a 'sea of green' and assure you that everything was okay?

- If you saw this in a 70-page performance report, how long would you spend considering it?

Busy decision-makers admit they often skip over data presented in this way.

- Why do you think they do this?

Report 2

- Did any of these graphs prompt more discussion and questioning?

- Did they provide you with assurance?

- What action would you take?

- Most people are concerned about the decline in indicator 2.

Report 1

- Did this feel like a 'sea of green' and assure you that everything was okay?

- If you saw this in a 70-page performance report, how long would you spend considering it?

Busy decision-makers admit they often skip over data presented in this way.

- Why do you think they do this?

Would you be surprised to learn that both reports use the same data source?

Did you notice the decline in indicator 2 in the 'sea of green'?

Report 2

- Did any of these graphs prompt more discussion and questioning?

- Did they provide you with assurance?

- What action would you take?

- Most people are concerned about the decline in indicator 2.

The time series is longer in report 2 and because of this you can appreciate how variable performance is over time. These charts are SPC charts. A bit later we look at the anatomy of a SPC chart but for now, take a few minutes to consider whether – even without understanding the detail of what a SPC chart is – you would have taken action if presented with this style of graph. Share your thoughts with us on Twitter using the **#plotthedots** hashtag.

From this example you should appreciate that **how** we visualise data is just as important as **what** we visualise if we want to make the most informed decisions.

Are you surprised at the different conversations you had about the same data?

These papers give a really good description of why the red, amber, green (RAG) reports can be misleading if used inappropriately.

From stoplight reports to time series: equipping boards and leadership teams to drive better decisions

The problem with red, amber, green: the need to avoid distraction by random variation in organisational performance measures

This paper critiques the use of league tables within health and discusses the use of time series.

Performance league tables: the NHS deserves better

An Open Athens account provides access to the full content of these papers. NHS employees are eligible for a free account. Click here.

Evidence, evidence, evidence

In the 1920s, Walter A Shewhart, an American physicist, was tasked with improving the quality of telephones in Bell Laboratories. His efforts played a key role in significantly improving the quality of manufactured products over subsequent decades. As part of his work, Shewhart developed a theory of variation which forms the basis of SPC.

This theory categorises variation into expected (**common cause**) and unusual (**special cause**). In turn, this guides what type of action is required – which in some cases may be none. All too often, we overreact to variation which is normal – we waste lots of time investigating a 'deterioration' which SPC tells us is normal; wild goose chases. Another word for this is tampering. Tampering is not a good thing as it distracts you from situations that merit focus.

In the real world everything varies: how long it takes to travel to work, how long it takes to record a patient's blood pressure, how many patients need a home visit? Think about your journey to work: does it take the same time every day or does it vary? It will be slower if there is more traffic, the ticket machine is broken, there is a queue for the lift… This is an example of what is called 'common cause' variation; variation that is outside your control. You can't say exactly how long your journey to work will take on any particular day, but you can give a range for what is expected.

Have you ever arrived at work an hour late because your train broke down or there was a strike? These are examples of 'special cause' variation – the event that caused you to be late is already understood. In other cases the reason for unexpected variation may need to be investigated.

While SPC has its roots in manufacturing, increasingly SPC is being used in healthcare. By recognising which type of variation you are dealing with, you can take the best action to deliver improvements. There are countless examples of SPC being used to demonstrate improvements in patient care. SPC also has an important role in clinical governance and avoiding harm.

The science and theory that underpins statistical process control

Dr Thomas Woodcock, Information Theme Lead for CLAHRC Northwest London, describes the science and statistics that underpin the analytical approach called statistical process control (SPC). He explains why SPC was developed and describes how it is a useful approach to use in the NHS to support improvements in care.

Here are some published papers which demonstrate the benefits of SPC in healthcare.

Case study evidencing the impact of discharge to assess on length of stay

Statistical process control as a tool for research and healthcare improvement

Using SPC to improve healthcare

Lessons from variation with case studies from healthcare, including Bristol and Shipman

An Open Athens account provides access to the full content of these papers. NHS employees are eligible for a free account. Click here.

Why analysts and decision-makers need to work together and how to do it

People with analytical skills are best placed to identify how data can be presented to ensure that it is both effective and meaningful. They are often not the people required to make decisions and take action. It is therefore extremely important that the people making decisions and those with skills to analyse and present data are connected – richer discussions will take place and better outcomes will be achieved.

By talking to each other the analyst and decision-maker can tease out the precise question that needs answering; ensure that the most appropriate data is analysed and presented in the most meaningful way; and explain the key messages from the analysis. The decision-maker can provide the all important operational context.

The role of time series data in improving care

Dr Bob Klaber, Consultant Paediatrician, Imperial NHS Trust, Describes why it is important that time series data is regularly fed back to clinical teams. He explains the vital role that SPC has in evidencing whether changes made by clinicians are having a positive impact.

But all too often analysts, managers and clinicians work in isolation from each other, without the benefits from collaborative working. So we encourage you to seek each other out. If you're an analyst, contacting your key decision-makers and clinicians probably isn't that difficult; you may already be receiving queries from them but not built up a strong working relationship. Tracking down analyst teams can be more tricky. They are sometimes found in a remote corner of your organisation; check the basement and any outlying Portakabins first!

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Here are some tips to help analysts and decision-makers work most effectively together.

Top tips when dealing with analysts

1. Bring cake/biscuits/limited edition Star Wars merchandise.

2. Talk to them, don't just email.

3. Explain the context and processes associated with the data.

4. Include them in the conversation as early as possible.

5. Listen to their recommendations.

6. (Did we mention bring cake/biscuits/limited edition Star Wars merchandise?).

Top tips when dealing with decision-makers

1. Ask lots of questions and clarify the request before you start.

2. See whether it is possible to meet/shadow people working in the relevant area.

3. If you are asked for something which is not meaningful, suggest an alternative.

4. Provide narrative to support your analysis.

5. Meet your decision-maker to discuss your analysis rather than emailing them.

Later in this guide we provide a range of exercises for you to work through as a combined team.

By now we hope you appreciate how critical data is to making best decisions, and want to find out how you can help your organisation make best use of data through meaningful visualisation and analysis.

We hope that you now understand the benefits of simply plotting the dots and visualising data over time.

The next step is to teach you a bit more about variation and introduce you to a SPC chart: its anatomy, a tiny bit of the science and, importantly, why this is a critical tool in your tool box – regardless of your role.
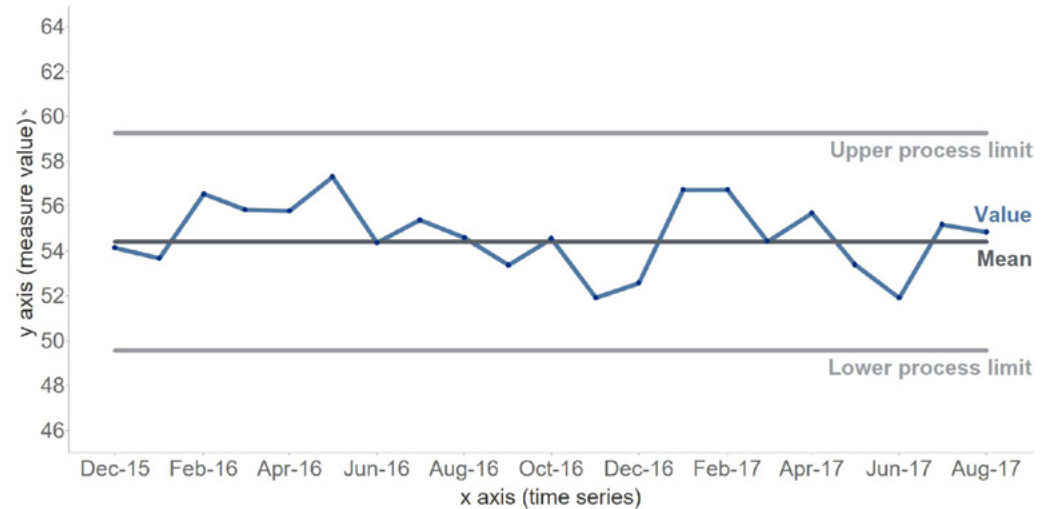
Statistical process control (SPC) chart – basic anatomy

We explain the value SPC brings to a time series of data.

This is a SPC chart.

It's a time series line chart with three reference lines that help you appreciate variation in the data. The reference lines are:

- centre reference line: the average line (often represented by the mean, sometimes the median)

- upper and lower reference lines: the process limits, also known as control limits.

You don't set the limits – these are defined by the variability of data for the measure you are plotting. You can expect approximately 99% of data points to fall within the process limits. Don't worry about the detail of why this is the case for now – it's all to do with probability and we'll talk about that a bit more later.

But from knowing that roughly 99% of data points will fall within the process limits, you start to appreciate how useful SPC is when you need to consider how likely it is that a target will be achieved.
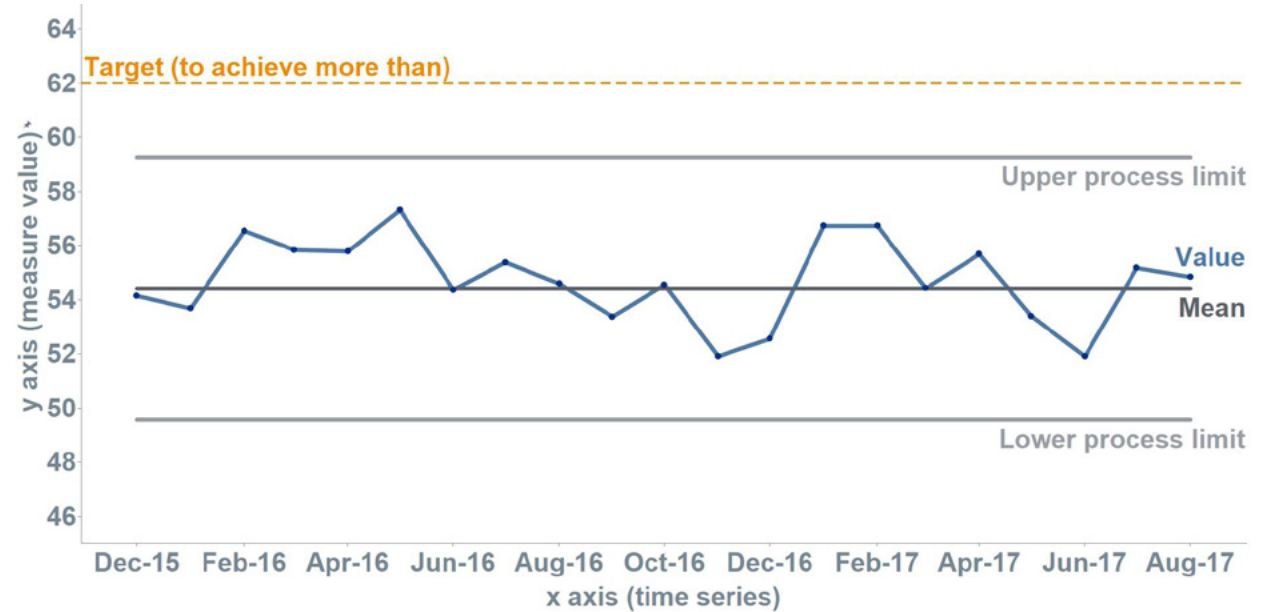
Here is the same chart but with an additional reference line showing the target.

The target line is above the upper process limit (and what you want to see is this limit above the target) – so you cannot expect to hit the target; doing so would represent a highly unusual occurrence as approximately 99% of values fall within the process limits.

Remember sometimes the objective is to be higher than the target and sometimes lower:

- If higher, a target above the upper process limit cannot be expected to be achieved.

- If lower, a target below the lower process limit cannot be expected to be achieved.

Remember sometimes the objective is to be higher than the target and sometimes lower:

When the target line lies outside the process limits (above or below), reacting to a data point when it goes up or down will not improve performance – it will simply waste valuable time and resources. You need to redesign the process. A good first step would be organising a process-mapping session with everyone who is involved with the process to ensure that it is fully understood. Changes can then be agreed, implemented and the impact measured. NHS Elect has produced a great guide on how to do this.

Here's a 10-minute video in which **Mike Davidge**, Director at NHS Elect, talks about how to measure improvement.

Guide to Measurement for Improvement

SPC rules: what are they and what do they tell you?

So, how can a SPC chart help you understand when something unusual is happening which needs to be investigated?

A set of rules allows you to interpret SPC charts. These rules provide the statistical rigour to help you understand when something unusual is happening in the system – for good or bad. Without these, it's left to interpretation; one person may say that's a clear change, another may say it's not!

In the same way you can calculate the area of a circle from knowing the value of Pi is 3.14 without understanding how this value was reached, you can benefit from the outputs of a SPC chart without understanding how the rules governing it were derived.

We have already described a SPC chart as a time series line chart with three reference lines showing the mean and the two process limits. Now we describe the three most useful rules that apply to healthcare.

A single point outside the control limits

Whenever a data point falls outside a process limit (upper or lower) something unexpected has happened because we know that 99% of data should fall within the process limits.

Here is an example of a much higher waiting time in A&E for a particular month. This disruption was caused by a new software system taking a little time to bed in.

Average wait per breach (crowding)
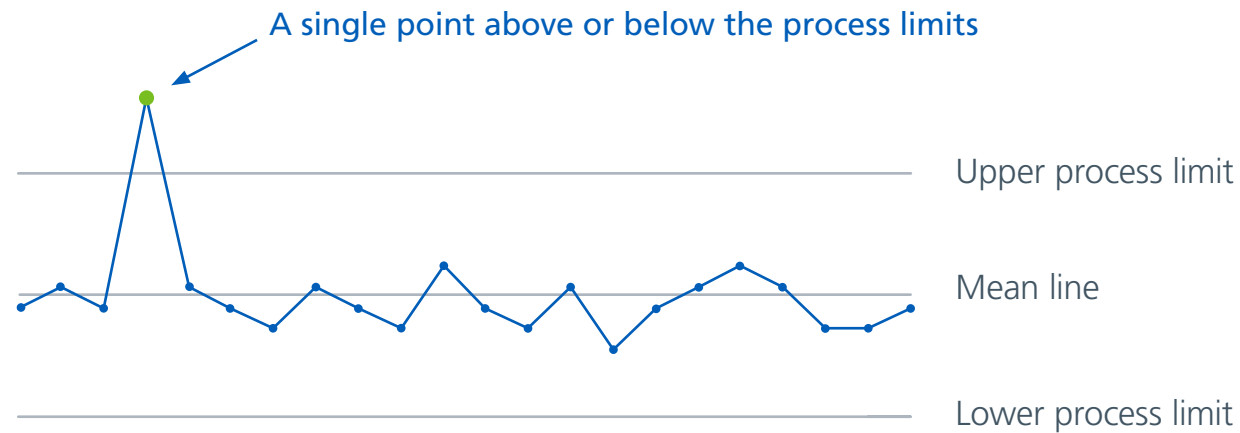
A single point above or below the process limits

Upper process limit

Mean line

Lower process limit

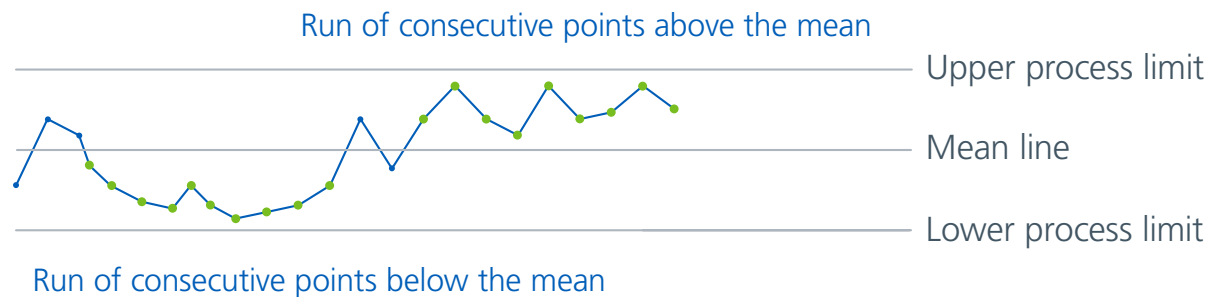## Consecutive points above or below the mean line

A run of values above or below the average (mean) line represents a trend that should not result from natural variation in the system.

Here is an example of an improvement project being implemented in an outpatients department. Initially, you can see that the changes made had a positive effect on waiting times. This was sustained for 10 months but funding was withdrawn and waiting times deteriorated as a result.

Initial assessment times

Run of consecutive points above the mean

Upper process limit

Mean line

Lower process limit

Run of consecutive points below the mean

The key consideration in this rule is how many data points you decide represents special cause variation. Most people use between seven and nine points. You should decide the number based on how frequently you want to ask questions of your system or process. The lower the number the greater the chance special cause variation will be identified. If data is provided monthly, you might want to use six points as six months is long enough to see any improvement. But if your data is provided daily, you may choose a higher number to avoid too frequent interventions. What you can be sure of is that a run of fewer than six points is insufficient as this can occur randomly and could result in you tampering with your system unnecessarily.

Six consecutive points increasing or decreasing

A run of six or more values showing continuous increase or decrease is a sign that something unusual is happening in the system.

In this example, a trust implements an early warning communication system for serious cases arriving at A&E who are likely to require an inpatient admission. The flow through the system improves with fewer breached admissions.

Breach admitted

Upper process limit

Mean line

Lower process limit

A long run of consecutively decreasing points
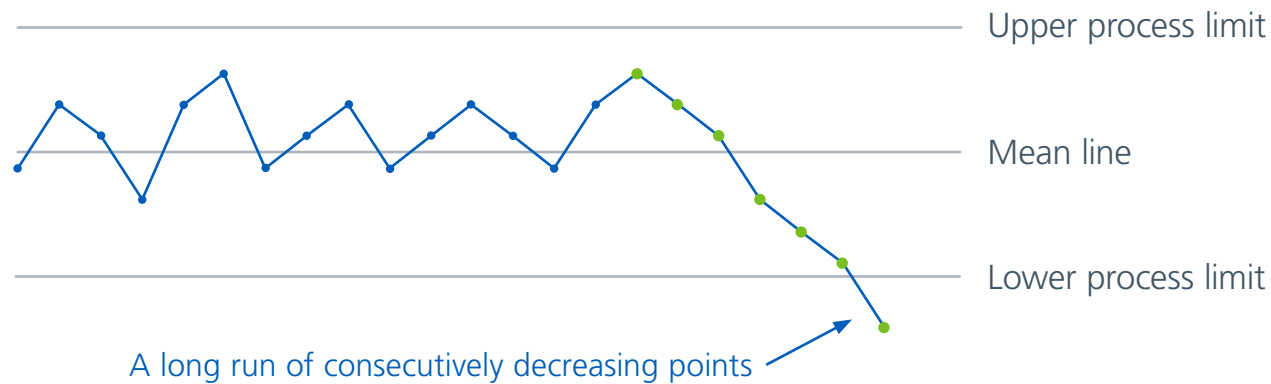
It does not matter where the run starts or finishes in relation to the mean line and it is widely accepted that six data points are sufficient to represent special cause variation. How many times have you heard people talking about a trend when this trend consists of two or three data points? For robust interpretation, a trend needs to have at least six points.

Remember that if you find your dataset fits one or more of these rules, then something unusual has happened – generally referred to as *special cause variation*.

The three rules work together – you don't necessarily have to wait for six or seven time periods to elapse to identify that there has been a change; this could be seen in a single significant point, or the build-up of a pattern of six to nine points.

If you find special cause variation, you need to investigate what is going on. This may be deteriorating performance which you need to understand and then take action to resolve. It may be an improvement which you need to learn from and sustain or spread to other parts of the organisation.

Game to appreciate random chance

Two or three points do not make a trend. If you want to see why, toss a coin. How long does it take you to toss three consecutive heads? You'll be surprised how often this can happen and perhaps worried about how often decisions are made on simple patterns that can be easily generated randomly.

Note: If it takes you more than 14 attempts, you're unluckier than most! Fourteen may sound a lot but now consider how many indicators there are in your local performance report (>100?) and how much data has been recorded (5 years/60 months). Hopefully you'll realise the scope for random patterns!
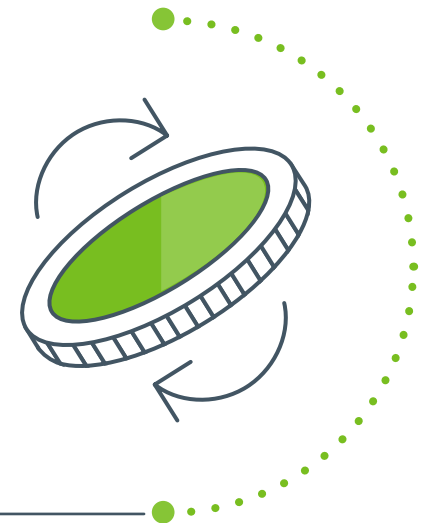
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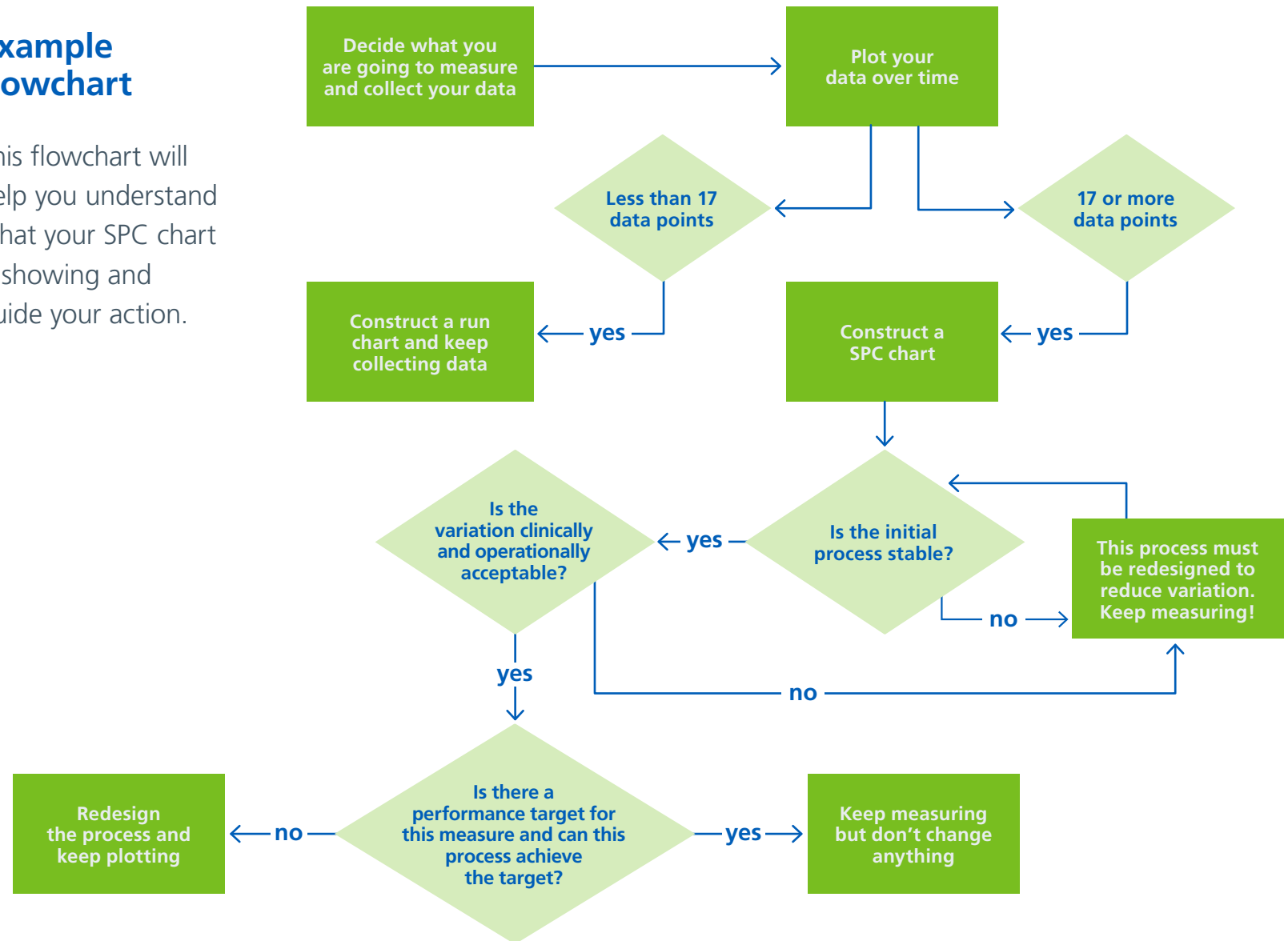
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Example flowchart

This flowchart will help you understand what your SPC chart is showing and guide your action.

Decide what you are going to measure and collect your data

Plot your data over time

Less than 17 data points

17 or more data points

Construct a run chart and keep collecting data — **yes**

Construct a SPC chart — **yes**

Is the variation clinically and operationally acceptable? — **yes** — Is the initial process stable?

This process must be redesigned to reduce variation. Keep measuring!

no

yes

no

Redesign the process and keep plotting — **no** — Is there a performance target for this measure and can this process achieve the target? — **yes** — Keep measuring but don't change anything
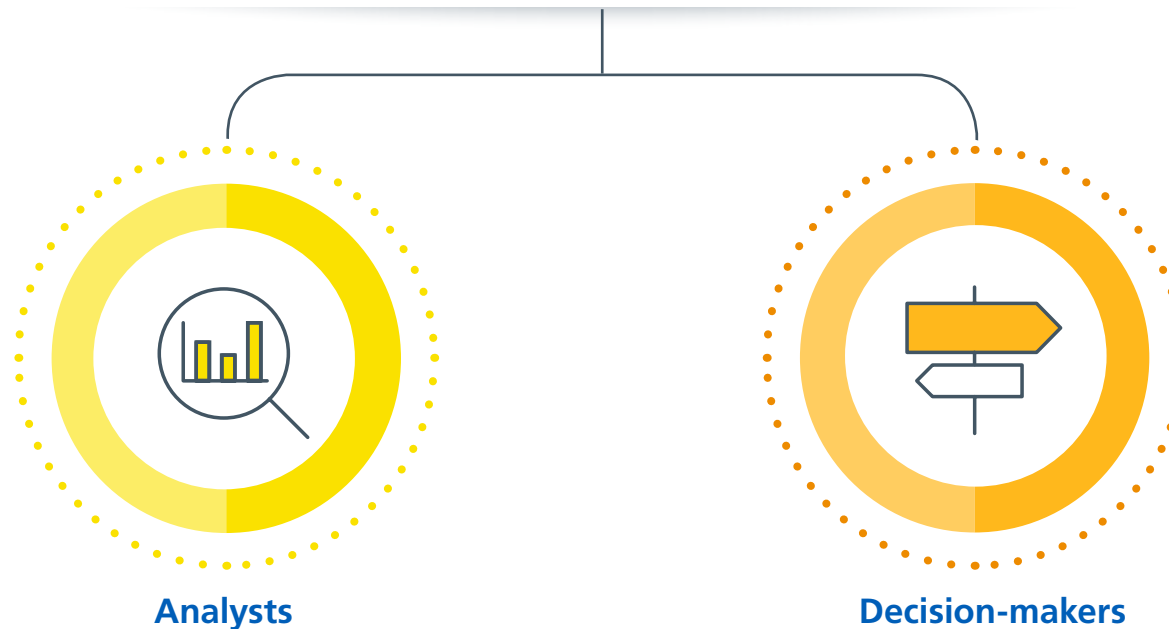
What's next?

Now we have introduced you to the benefits of looking at data over time, using SPC and working collaboratively, we'll provide some additional detail useful to people in analytical roles and those of you who are decision-makers – to help each role support the other.

Choose your pathway...

Analysts

Decision-makers

Welcome to the 'analysts' section

Primarily for those who have a role in data collection, analysis and visualisation. We will:

- suggest some approaches to best support decision-makers

- provide further technical detail which you need to understand

- explain how to create SPC charts.

If you don't have a technical role, please feel free to read on because an appreciation of these topics can only be beneficial.

How many of the following statements resonate with you in your day-to-day work?

Select all that apply and maybe compare your experiences with those of a colleague.

My data analysis and visualisation skills have been carefully developed by my organisation.

I always know how the analysis I produce is used once I've sent it off to colleagues.

I'm encouraged to ask questions about what my analysis shows and discuss this with colleagues.

I know who the key decision-makers are in my organisation and have met them.

Effective use of data is everyone's business around here.

I feel able to challenge poor use of data.

How many have you selected?

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What did you score?

0 ticks

Your experience is similar to that of many analysts we have talked to. Part of the purpose of this section is to encourage you to think about the skills you have and contribution you can make to the effective use of data for better judgement. So read on for hints and tips on how you can influence use of data in your organisation, including insight from people who have been right where you are now.

1-2 ticks

Some green shoots in your organisation; it sounds like you have some good local behaviours to build on. This section contains links to tools that can help with the rest and insight from people who have been on the same journey.

3-4 ticks

Sounds like your experience is really positive, with the use of data for better judgement central to what you do. This section contains videos in which people talk about the challenges of embedding measurement for better judgement approaches within their organisations.

5-6 ticks

If you're not one of the people in the videos in this section we'd like to hear more about the amazing place you work! Please join the community and help us spread the word. This section will reinforce much of the good work familiar to you but give you some new ideas too.

One thing that all analysts can do is change the way they present data to their colleagues.

Take a moment to do a quick calculation; what proportion of the regular reports you produce have 'traffic lights' on them?

- Most

- Some

- Hardly any or none.

"Tracking improvement over time is a critical component of all improvement strategies and to ascertain what key characteristics and interventions are associated with better outcomes."

Dr Matt Inada-Kim, National Clinical Advisor Sepsis and Deterioration

Supporting decision-makers

A practical way to persuade decision-makers to consider an alternative approach to data presentation is to recreate some of your RAG reports as SPC charts – is there a compelling story that you can share with your decision-maker?

Remember you'll need to explain to your decision-maker what your analysis shows. A written explanation is a good first step – but also take the time to sit down with your decision-maker. Investing time in this way will make your analysis a more powerful tool as it will ensure correct decisions and it will build your relationship.

It is easy to create a SPC chart but to retain two-point comparison thinking. This is something to guard against. Make sure your commentary reflects what the whole chart is saying – if the data is within expected variation don't confuse the issue by talking about increases and decreases as these are random occurrences.

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In this example, despite drawing the process lines to indicate where random variation is likely to fall, a misleading comment has been attached to the graph. It summarises what the last two points only show. A better comment might be that "this month waiting times continued to be subject to random variation".

Waiting times

Waiting times increased this month... ✖
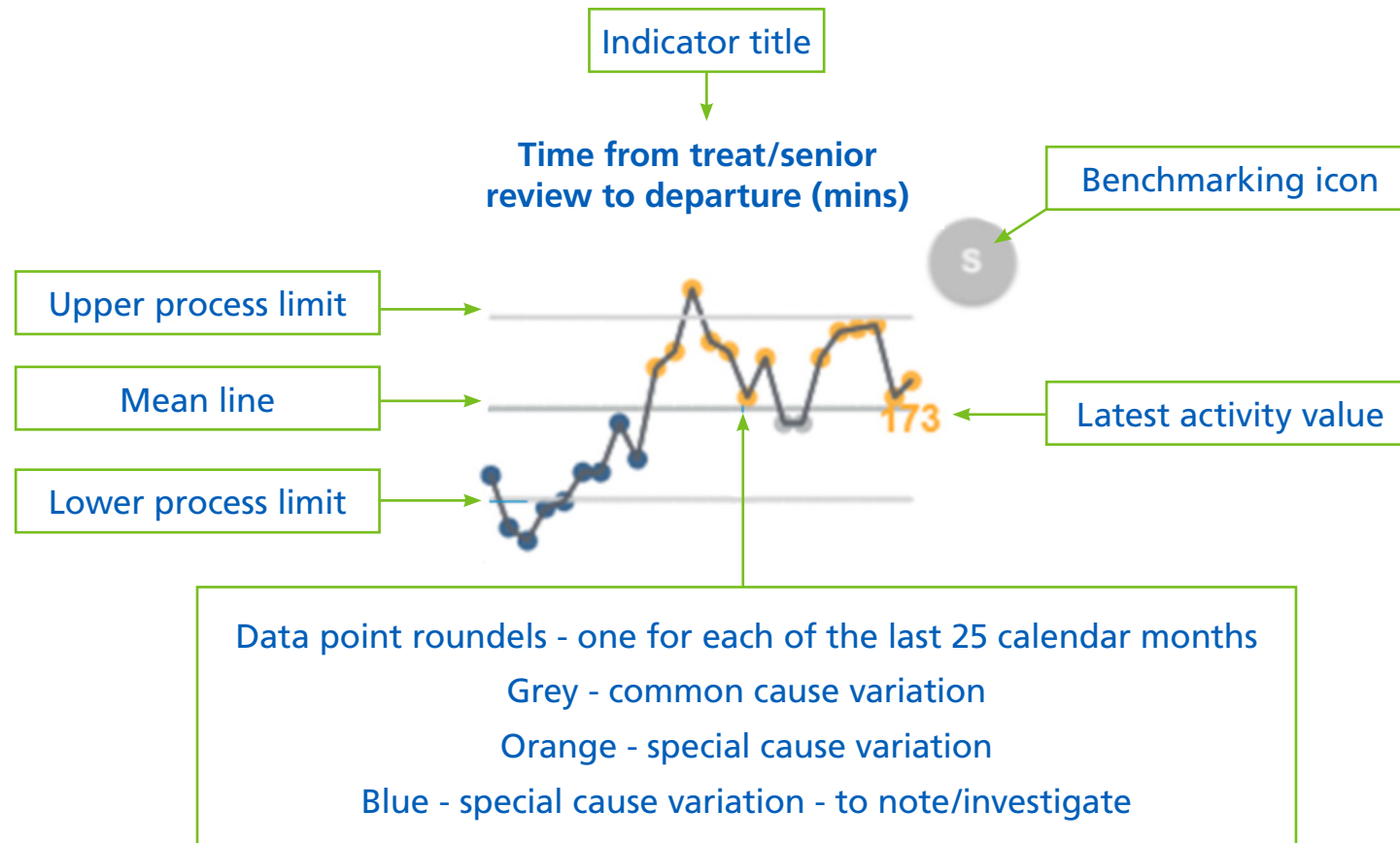
Think about how you can make the messages from the data clear and simple. In the example below, taken from the **Emergency Flow Improvement Tool**, colour has been used to differentiate between common cause and both good and bad special cause variation.

Indicator title

Time from treat/senior review to departure (mins)

Benchmarking icon

Upper process limit

Mean line

Lower process limit

Latest activity value

173

Data point roundels - one for each of the last 25 calendar months

Grey - common cause variation

Orange - special cause variation

Blue - special cause variation - to note/investigate

You can, no doubt, come up with even more innovative ideas to bring the data to life when you set your mind to it.

Technical detail

We have talked about the common rules used to interpret SPC charts, but is there any extra information an analyst needs to understand when creating these charts? Here are answers to some frequently asked questions regarding SPC fundamentals.

What's the minimum number of data points needed to create a SPC chart and what should I do if I don't have enough?

The most robust charts – that is, those that allow accurate decision-making, will be drawn from datasets with more than 20 time series data points.
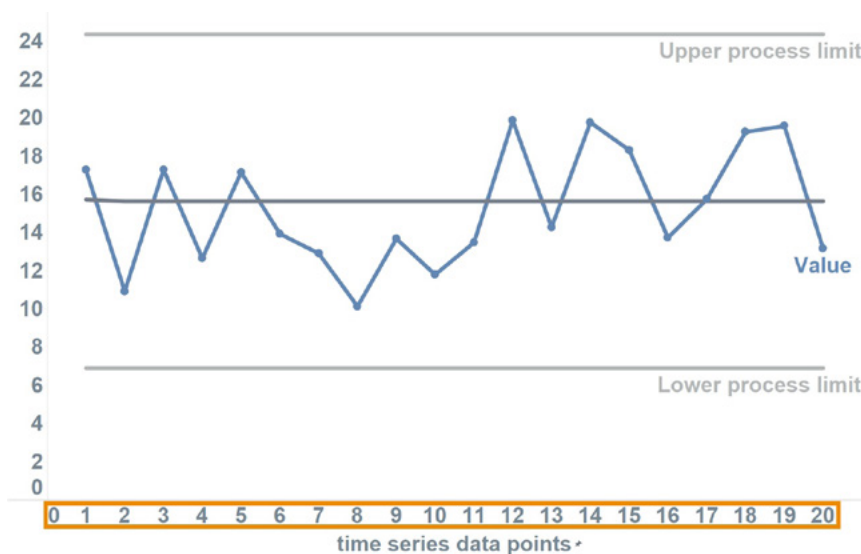
This example dataset has a history of 20 points – in most cases this will be sufficient to create robust process limits.

For fewer than 20 points, and certainly fewer than 10, you can draw a run chart, which is a time series line chart with a median line drawn through it. This will help you understand patterns and trends in the data. You can convert the same data to a SPC chart when you reach a robust number of points. You will find examples of SPC charts drawn from as few as 10 points; such charts can compromise decision-making.
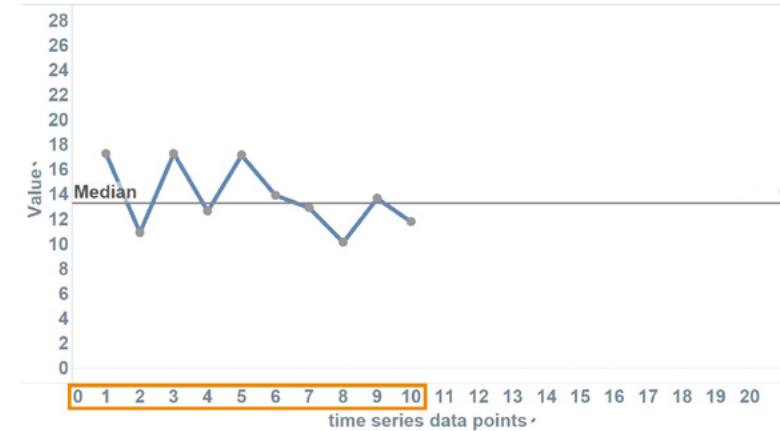
This dataset with only 10 data points is best shown as a run chart; there is not enough data to get a robust appreciation of variance.

Run chart

There are many types of SPC chart. Which one should I use?

The mathematical construction of SPC charts varies slightly so it may be that a particular chart provides greater sensitivity for your dataset.

If you are new to SPC, we suggest that you start with the Xmr chart – considered to be the 'Swiss army knife' of SPC charts and versatile enough to handle all data types. Should you wish to become more advanced, have a look at the reading list at the end of this guide or join the community.

Find out how to join the virtual community of interest here

How do I draw a SPC/Xmr chart?

It's not as hard as many think: all the lines are based on averages with some simple multiplication thrown in. Many start their development in Microsoft Excel which allows you to create formulas and do calculations quickly. For bigger datasets and more ambitious projects we've seen some great work in Tableau, Alteryx, Power BI, SQL server and Reporting services. Whatever your system, someone in the 'community' will have a practical solution… so join!
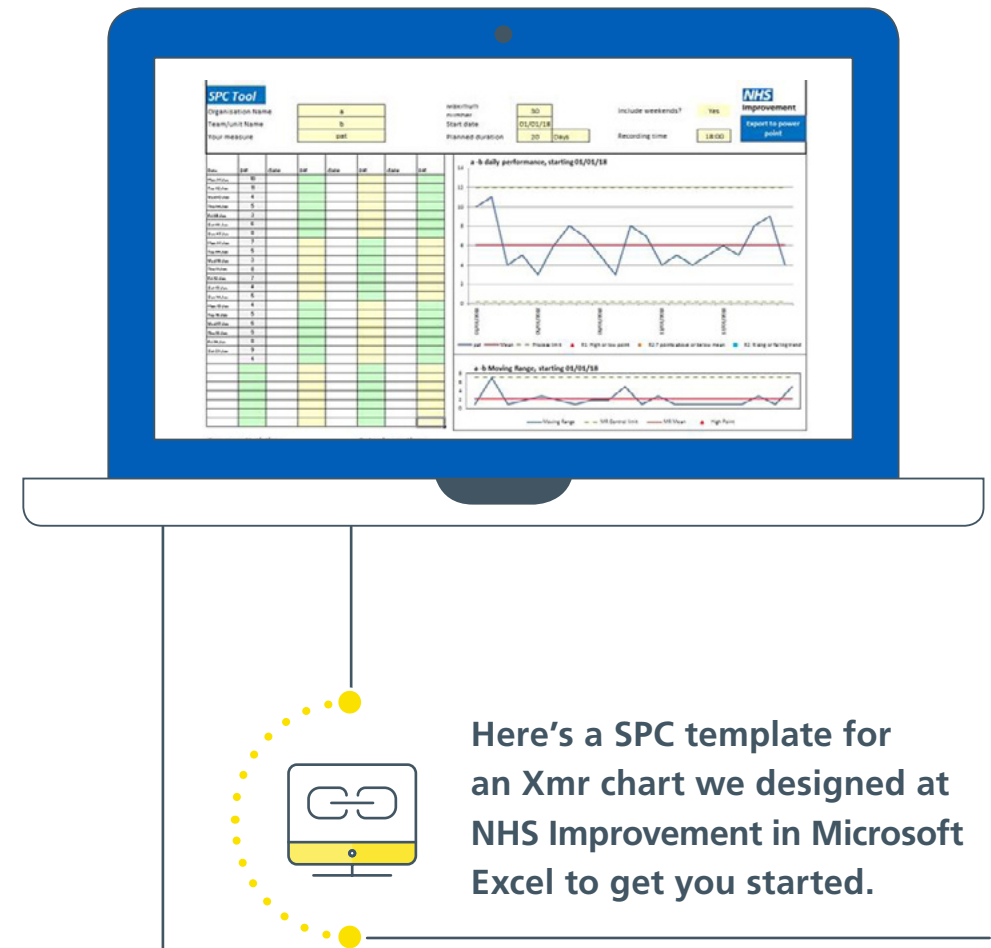
Here's a SPC template for an Xmr chart we designed at NHS Improvement in Microsoft Excel to get you started.

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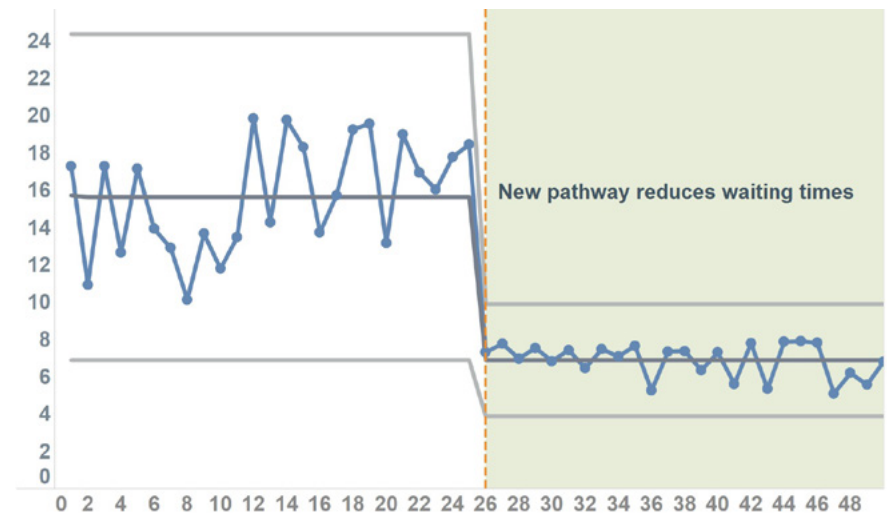
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Should I recalculate the mean and process limits when an improvement (or decline) has been identified?

Before redrawing the mean and process limits you need to be certain the system has fundamentally changed. Engage with the system (maybe a clinic or ward) from which the data is collected and understand the reason for the change.

Maybe a new pathway has reduced waiting times so dramatically that the team now wants to redraw the mean and limits around this new system so they can attempt another improvement cycle, rather than forever monitoring against the original system.

What you don't want to do is automatically redraw the chart every time you see a rule indicating improvement or decline. You need to first question the system, understand the cause and then only if, working with others, you're sure there's a new system, redraw the mean and limits from the point the new system was introduced. When redrawing don't forget you need a minimum number of data points for an informative SPC chart. So if you previously decided you needed 20 points to draw a robust SPC chart, you will need 20 points from the new system to get an equally robust picture.

New pathway reduces waiting times

Cheryl Davies, the Project Manager for the Ambulatory Emergency Care and Acute Frailty Network at University Hospitals Southampton NHS Foundation Trust, found there was some confusion about SPC rules and who needed to know what...

STOP! Before you hear what Cheryl did about this problem, think about your own practice and that of your team. What would you do? How would you handle this issue with your clinical or managerial decision-maker colleagues?

Now hear what Cheryl and her team did next.

Fatai Ogunlayi, Quality Improvement Lead at Imperial College NHS Foundation Trust, gives insight into how he has managed to influence decision-makers to ask for the most useful analyses of data...

STOP! Before you hear what Fatai did, think about your own practice and that of your team. What would you do? How would you respond to a similar challenge from your clinical or managerial colleagues?
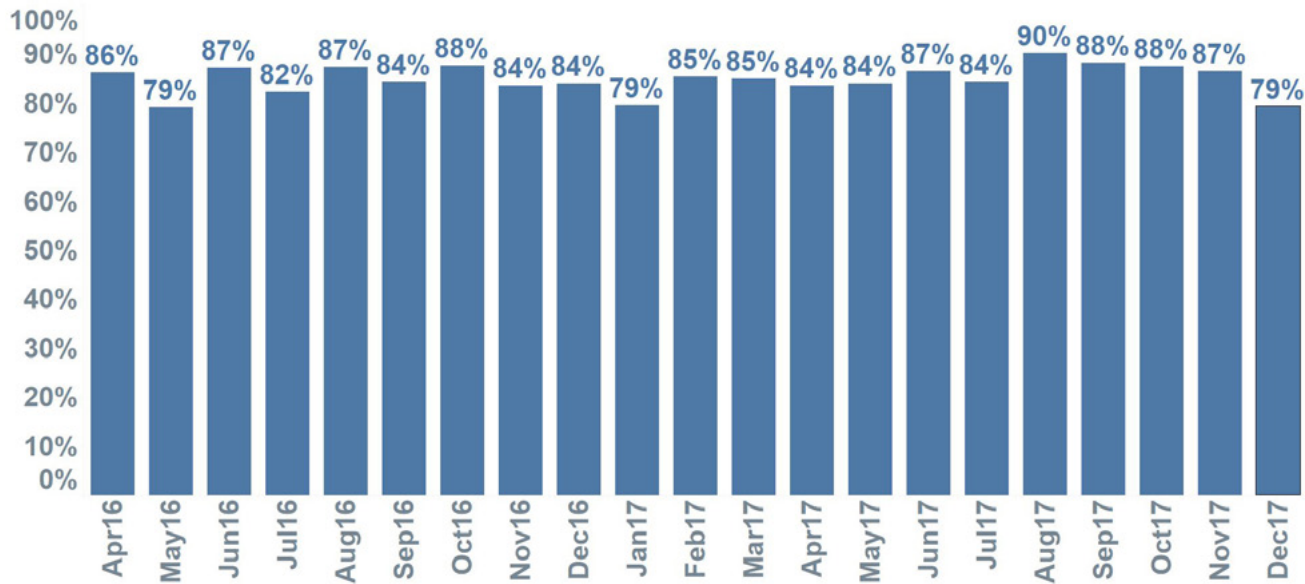
Now hear what Fatai and his team did.

Scenarios for analysts

Scenario 1: Understanding variation

The assistant director of performance has come to see you to discuss the graph below ahead of the board performance report.

Successful outcomes

Apr16 86%, May16 79%, Jun16 87%, Jul16 82%, Aug16 87%, Sep16 84%, Oct16 88%, Nov16 84%, Dec16 84%, Jan17 79%, Feb17 85%, Mar17 85%, Apr17 84%, May17 84%, Jun17 87%, Jul17 84%, Aug17 90%, Sep17 88%, Oct17 88%, Nov17 87%, Dec17 79%

The trust observed a significant drop in performance in December 2017

Follow the conversation and think about the answers you might give now and what you might have said in the past.

Analyst (you)

A You're right – an 8% drop in a month is big.

B Are you sure there has been a significant change?

Performance manager

I see that there was significant deterioration in performance last month. I've already instructed the service manager to undertake an investigation and develop an action plan - the commissioners will want this. I might need your help to dig a bit deeper into the data.

Performance manager

I see that there was significant deterioration in performance last month. I've already instructed the service manager to undertake an investigation and develop an action plan - the commissioners will want this. I might need your help to dig a bit deeper into the data.

Analyst (you)

A You're right – an 8% drop in a month is big.

B Are you sure there has been a significant change?

Suggested answer B

Are you sure the change is significant? 8% does look like a big drop on this graph, but we've seen similar drops before, like in May 2016. It's hard to appreciate the natural variation in this dataset from the graph. I would want to understand this before spending time on an investigation as it might have been randomly caused.

Performance manager

Hmm, I'm not so sure, it looks like four months in a row of deterioration in performance, that's a strong trend.

Analyst (you)

A It's not that rare for a pattern of four consecutive points in time series data to be generated by random variation in the system.

B Yes, four months in a row is concerning. If it were two or three that could be chance, but four is a strong pattern.

Performance manager

Hmm, I'm not so sure, it looks like four months in a row of deterioration in performance, that's a strong trend.

Analyst (you)

A It's not that rare for a pattern of four consecutive points in time series data to be generated by random variation in the system.

B Yes, four months in a row is concerning. If it were two or three that could be chance, but four is a strong pattern.

Suggested answer A

It's not that rare to see a pattern of four in randomly generated time series data. In fact it could be as little as a one in 16 chance in a random system. We need to look at this data another way.

Analyst (you)

A A time series line chart.

B A statistical process control chart.

Performance manager

How? What would you suggest?

Performance manager

How? What would you suggest?

Analyst (you)

A A time series line chart.

B A statistical process control chart.

Suggested answer B

It is useful to look at data over time, but a SPC chart enables us to understand how variable the data is over time and whether something unusual happened in December.

Analyst (you)

You draw a statistical process control chart. What does it tell you?

A **The most recent data point is one of the three lowest on the chart. Given we are viewing 21 data points, this is significant.**

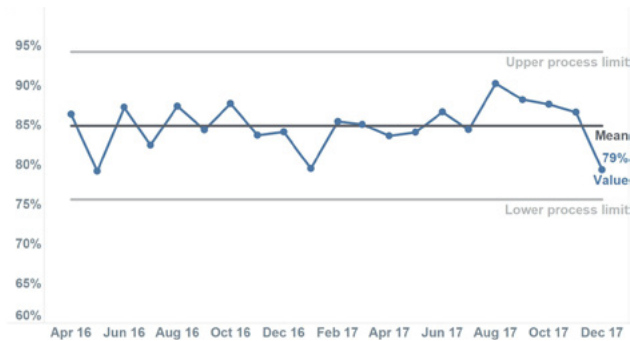**B** **No significant drop is seen in the SPC chart for December 2017.**

Analyst (you)

You draw a statistical process control chart. What does it tell you?

A The most recent data point is one of the three lowest on the chart. Given we are viewing 21 data points, this is significant.

B No significant drop is seen in the SPC chart for December 2017.

Suggested answer B

From looking at the SPC chart, the process limits tell us that we can expect performance to range from 75% to 94%. There are no patterns in the data indicating that something unusual happened in December. An investigation and short-term action plan will not help. I'd recommend we contact the improvement team and ask them to facilitate a process mapping session so that we can understand and redesign the process.

Scenarios for analysts

Scenario 2: Redesigning the system

You're told the trust's mandatory training has been below target for the third consecutive month.

	Target	Jul 2017	Aug 2017	Sep 2017	Year to date average
Training compliance	90%	85.4%	86.1%	85.5%	84.6%

A project group has been set up and you've been invited to give your opinion on the data. Follow the conversation and think about the answers you might give now and how you might have responded in the past.

Project manager

Three consecutive months of failed targets and the year to date average also below target. I see no alternative but to take a new approach – replace the training system, change our communications plan, the culture, everything. Is everyone in agreement?

Analyst (you)

A I agree. We're not meeting the target, this month, last month and the overall average for the year to date.

B Let's do some further analysis; while we can only see failure in this table, we only have three months of data and an aggregate position.

Project manager

Three consecutive months of failed targets and the year to date average also below target. I see no alternative but to take a new approach – replace the training system, change our communications plan, the culture, everything. Is everyone in agreement?

Analyst (you)

A I agree. We're not meeting the target, this month, last month and the overall average for the year to date.

B Let's do some further analysis; while we can only see failure in this table, we only have three months of data and an aggregate position.

Suggested answer B

Let's do some further analysis; while we can only see failure in this table, we might be missing a longer-term trend. In addition the average masks variation and is of limited value.

Project manager

Well all I can see is red! What do you suggest? If we expand this table out to 12 months will that help?

Analyst (you)

A I think we'd want in the region of 20 months/data points to get a good picture of what's been happening.

B Yes, a full calendar year of data will be meaningful; it will also mean we don't miss any seasonal trends.

Project manager

Well all I can see is red! What do you suggest? If we expand this table out to 12 months will that help?

Analyst (you)

(A) I think we'd want in the region of 20 months/data points to get a good picture of what's been happening.

(B) Yes, a full calendar year of data will be meaningful; it will also mean we don't miss any seasonal trends.

Suggested answer A

If you can provide 20 months of data that would be great. That's enough data points to be able to see any patterns in the data that might change our decision about what it's best to do.

Project manager

Okay, we've been running this system for many years and reporting the numbers each month. Can you analyse the data for us?

Analyst (you)

You locate the data from April 2015, draw a SPC chart and bring it to the next meeting.

Target (90%)

Actual 85.5%

Upper Process Limit 84.9%

Mean 82.6%

Lower Process Limit 80.4%

Mar-15 Jun-15 Sep-15 Dec-15 Mar-16 Jun-16 Sep-16 Dec-16 Mar-17 Jun-17 Sep-17

Analyst (you)

A This is special cause variation – a SPC rule has been activated. I decided to colour it green to signify improvement.

B It's green if it's above the average, indicating improvement.

Project manager

I can see we're miles below target and we've never been close. I feel the same as before? Why have you highlighted the recent dots in green when we are clearly failing?

Project manager

I can see we're miles below target and we've never been close. I feel the same as before? Why have you highlighted the recent dots in green when we are clearly failing?

Analyst (you)

(A) This is special cause variation – a SPC rule has been activated. I decided to colour it green to signify improvement.

(B) **It's green if it's above the average, indicating improvement.**

Suggested answer A

The SPC chart identifies a recent unusual pattern in the data. I decided to colour it green as this pattern indicates improvement. A good idea before we take a totally new approach would be to investigate what changes have been made which might have resulted in this improvement. There might be more that needs to be done to achieve the target, but something positive is clearly happening.

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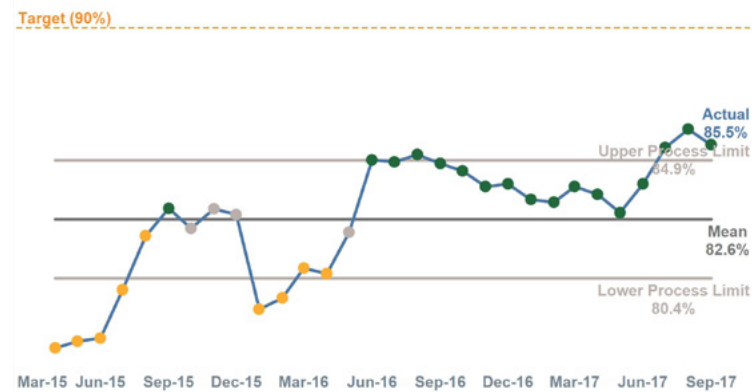Doing it together

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Scenario 3: Highlighting variation with the board

A key target has been missed for the first time this financial year and the board is surprised as this did not feature on its exception report. The board is disappointed not to have had early warning of this failure, and asks you to discuss the board report to provide some insight. Follow the conversation and think about the answers you might give now and how you might have responded in the past.

	Target	Apr 2017	May 2017	Jun 2017	Jul 2017	Aug 2017	Sep 2017
Patient dissatisfaction with treatment	less than 3%	2.4%	2.5%	2.2%	2.5%	2.6%	3.1%

Board member

We have not seen this indicator on our red list for such a long time and as a result we are not prepared for this outcome – surely you have methods to provide us with an early warning?

Analyst (you)

A I couldn't have given you any earlier warning on this – we've not been close to the target all year, something major has happened this month, it couldn't have been foreseen I'm afraid.

B We need more than six months of data to judge the likelihood of hitting the target in future months.

Board member

We have not seen this indicator on our red list for such a long time and as a result we are not prepared for this outcome – surely you have methods to provide us with an early warning?

Analyst (you)

A I couldn't have given you any earlier warning on this – we've not been close to the target all year, something major has happened this month, it couldn't have been foreseen I'm afraid.

B We need more than six months of data to judge the likelihood of hitting the target in future months.

Suggested answer B

Six data points is too few. If we take data for a longer time period, I can draw a SPC chart. This will provide an indication of the likelihood that we will hit the target in future.

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You locate the data from April 2015, draw a SPC chart and bring it to the next meeting.

Upper Process Limit
3.4%

Actual 3.1%

Target (< 3%)

Mean
2.7%

Lower Process Limit
2.0%

Mar-16 May-16 Jul-16 Sep-16 Nov-16 Jan-17 Mar-17 May-17 Jul-17 Sep-17

Board member

What can you tell us about this chart?

Analyst (you)

A The target line falls within the process limits so we can never be sure that this system will hit the target every month.

B The target line is above the average. We should hit this target most months. When we don't, something significant will have happened, like this month.

Board member

What can you tell us about this chart?

Analyst (you)

A **The target line falls within the process limits so we can never be sure that this system will hit the target every month.**

B **The target line is above the average. We should hit this target most months. When we don't, something significant will have happened, like this month.**

Suggested answer A

The target line falls within the process limits. 99% of data points fall within these limits. Random variation in the system might be enough for the target to be missed for a particular month.

Board member

This is very useful knowledge but how can we understand this for all of our targets? Our board report is already 100 pages long!

Analyst (you)

A I can create a list of metrics where the target is within the process limits to give you a feel for those indicators that may fail periodically so you can understand this risk.

B I'll plot every indicator as a SPC chart

Board member

This is very useful knowledge but how can we understand this for all of our targets? Our board report is already 100 pages long!

Analyst (you)

A I can create a list of metrics where the target is within the process limits to give you a feel for those indicators that may fail periodically so you can understand this risk.

B I'll plot every indicator as a SPC chart

Suggested answers A and B!

I'll plot every indicator as a SPC chart, but I will summarise the outputs for your board report. I will provide a summary page which shows whether each indicator is improving or deteriorating. If there is a target, I will signal whether the process limits show that the target can be reliably achieved. I will provide an annex of SPC charts for those indicators that should be discussed at the meeting.

What next?

This section has outlined some of the practicalities and challenges of adopting analytical approaches that support better judgement and decisions for action. Do revisit this section whenever you need to; follow the links to guidance and resources, get some inspiration from our experts or retake the six-point self-assessment checklist at the beginning to see how your organisation is progressing with the **#plotthedots** ethos.

Here are some practical actions that you can take now:

- Take **our quiz** to test your knowledge.

- Have a look at your RAG reports and see if you can create a compelling commentary using a SPC chart instead.

- Run an education session for colleagues explaining the benefits of SPC over RAG.

- Search out your key decision-makers.

- Talk to those who request information from you, rather than immediately responding.

find quiz here

?

Get involved!

Share your experiences on Twitter using **#plotthedots** and join our virtual community of interest for everyone striving to improve their use of data – currently we have nearly 800 members. As well as the opportunity to link up with **#plotthedots** fans, this will give you access to a wealth of resources and toolkits to make better use of data.

Email **nhsi.improvementanalyticsteam@nhs.net** if you would like to join.

Think about what you can do to encourage better use of data for judgement and decisions for action and make a pledge.

Go to template

I pledge to...

Write your pledge and share it on Twitter using **#plotthedots**

Welcome to the 'decision-makers' section

Welcome to the 'decision-makers' section – primarily for those who make day-to-day operational or strategic decisions based on reports of data, metrics, indicators and analysis. It will help you interpret data correctly to inform the best decisions.

You are probably bombarded daily with reports to review and need to base your decisions on what the numbers reveal about performance. Sounds exhausting! Knowing how to make best use of data will make you more efficient and your decisions better.

In this section we will expand on:

- the dangers to your organisation of over-reacting to data that shows 'common cause' (normal) variation

- the benefits of reducing variation

- how SPC charts can help when planning trajectories and targets.

Decision-makers, be they clinical or managerial, understand the day-to-day challenges faced in delivering health and care services but not necessarily the data on which they base judgements and decisions for action. Working with analytical colleagues you need to be able to identify what data you need, and how it can be collected and analysed to support you in making decisions.

Decision-makers are also the group who can influence the kind of change in reporting methods we recommend in this guide; by proactively using data you will be able to direct actions and evidence their impact. You are best placed to encourage the better use of data in improving performance.

Let's start by taking time to reflect. How many of the following statements resonate with you in your day-to-day work?

Tick all that apply and maybe compare your experiences with those of a colleague:

My data analysis and visualisation skills have been carefully developed by my organisation.

I always know who to ask if I have data-related questions.

The data I receive is always relevant to the day-to-day decisions I make.

I work closely with my analyst team to review and adjust reporting to meet my needs.

Effective use of data is everyone's business around here.

I feel able to challenge poor use of data.

How many have you selected?

What did you score?

0 ticks

Your experience is similar to that of many decision-makers we have talked to. Part of the purpose of this section is to encourage you to think about your approach to data and the contribution you can make to the effective use of data for better judgement. So read on for hints and tips on how you can influence use of data in your organisation, including insight from people who have been right where you are now.

1-2 ticks

Some green shoots in your organisation; it sounds like you have some good local behaviours to build on. This section contains links to tools that can help with the rest and insight from people who have been on the same journey.

3-4 ticks

Sounds like your experience is really positive, with the use of data for better judgement central to what you do. This section contains videos in which a non-executive director talks about how effective use of data for better judgement has at least partly solved common operational and strategic challenges.

5-6 ticks

We'd like to hear more about the amazing place you work!

Dangers of over-reacting to 'common cause' variation

The NHS is a data-rich environment. We measure so many things that we can quickly become swamped by numbers, tables and graphs – and unable to see the 'wood for the trees'.

Performance is measured against countless national targets, and on top of meeting these targets individual commissioners and trusts are striving to address their own priorities. If you over-react to a data point or a short series of data points that a SPC chart identifies as normal variation, you risk wasting lots of time and resource trying to answer the wrong question. Your decisions may make the whole system more variable or you may even implement a change that makes the situation worse. Only by understanding when observed change is significant, both statistically and operationally, can you direct action that uncovers what is at the root of these changes; effective plans to sustain or increase real improvement or manage real deteriorations in performance can then be developed.

This is where presenting data in SPC charts comes in – they tease out what merits investigation and action, and you are not distracted by variation that is due to chance in your current system.

Benefits of reducing variation

One of the biggest challenges in improving quality of healthcare is reducing variation. As we have already discussed there are two types of variation and they need to be approached differently. To reduce common cause variation, you need to change the process. Special cause variation results from things outside the system – like bank holidays or Christmas or process changes. To reduce special cause variation, you must identify the special causes and then take action to address these specifically.

Variation makes your system highly unpredictable and as a result your services difficult to plan for. Reducing variation will make you better able to predict demand and then plan for the capacity to manage it. For example, if you can accurately predict how long each operation on a theatre list will take, you can match the patients on a list to the time available and avoid over- and under-runs or cancelled cases. Also, wide variation can mask small but real improvements in a process – improvements that you and others could learn from.

Some excellent resources which talk more about demand and capacity can be accessed here.

Trajectories and targets

You can see what your system's expected range of performance is by looking at data over time in SPC charts. For example, in this chart showing a trust's performance against the A&E four-hour target, the process limits tell you the trust can expect to achieve a level of performance between 75% and 92%.

Remember that 99% of data points fall within the process limits. This trust is therefore highly unlikely to ever achieve the target level of 95%. A significant change in process is necessary to improve the level of performance. Plotting a trajectory or setting a target for the process outside its normal process limits is futile without planning such a change.

4 hour performance - All types
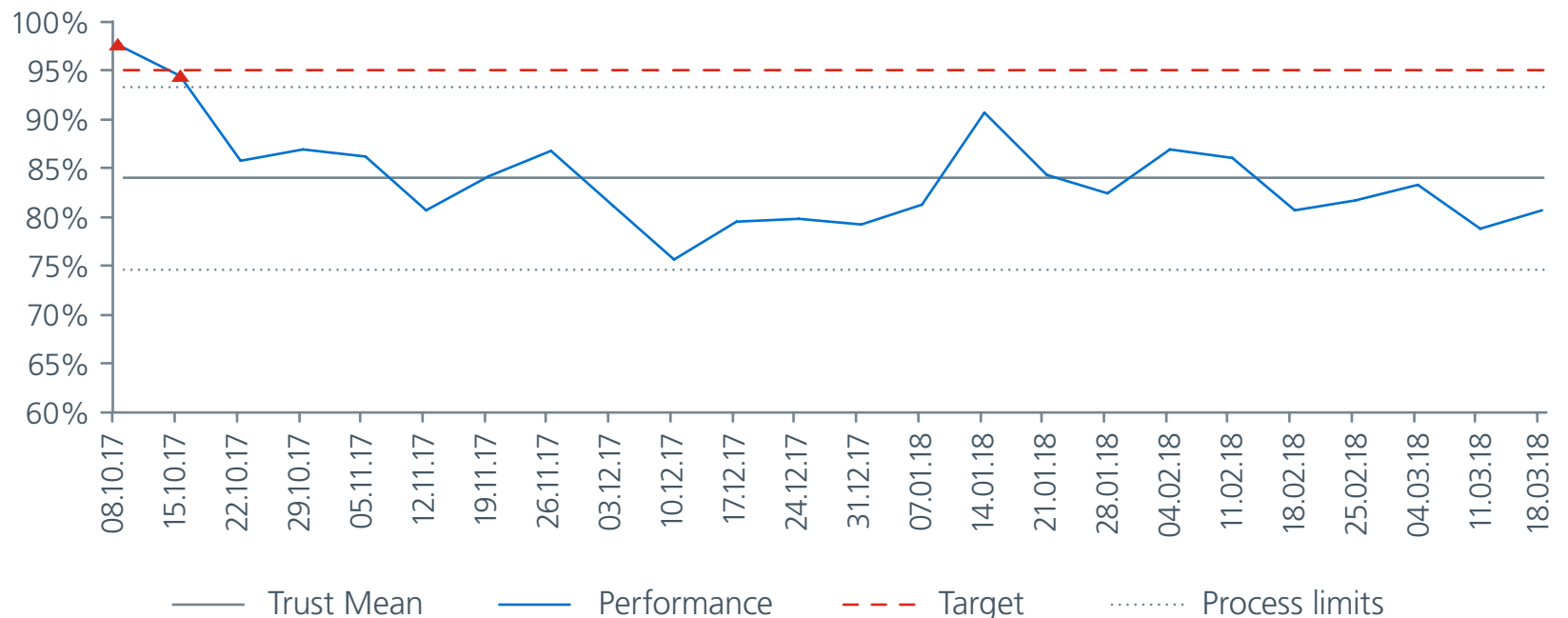
Scenarios for decision-makers

Scenario 1: Using SPC to identify improvement

You've been asked to assist with a project described as 'stagnating' and to come up with some ideas for improvement.

Before your first meeting an analyst emails you a SPC chart showing the project's performance to date. The higher the percentage, the more successful the project has been.

Follow this conversation and think about how you would respond now compared with how you would have done in the past.

Project support officer

I can see from the SPC chart that we've had some months when performance was better. Let's circle the best three months, find out why things went well and repeat what we did.

Decision-maker (you)

A Great idea, identify the best months and replicate what we did – that will help us improve.

B All the data points are within the process limits and no SPC rules have been triggered.

Project support officer

I can see from the SPC chart that we've had some months when performance was better. Let's circle the best three months, find out why things went well and repeat what we did.

Decision-maker (you)

A Great idea, identify the best months and replicate what we did – that will help us improve.

B All the data points are within the process limits and no SPC rules have been triggered.

Suggested answer B

All the data points are within the process limits and no SPC rules have been triggered. That means nothing different was happening in the months when performance appeared to be better.

Project support officer

Okay, but look at those four consecutive months ending in October 2017, all above the mean line, that's a trend that we could learn from?

Decision-maker (you)

A I hadn't noticed that. Four months certainly is a trend.

B We need more data points to be sure of a trend, a minimum of six or seven.

Project support officer

Okay, but look at those four consecutive months ending in October 2017, all above the mean line, that's a trend that we could learn from?

Decision-maker (you)

A I hadn't noticed that. Four months certainly is a trend.

B We need more data points to be sure of a trend, a minimum of six or seven.

Suggested answer B

It's not that rare for random variation in the system to generate a pattern of four in time series data. In fact the chance of this could be as high as 1 in 16.

Project support officer

All of my ideas seem to be falling on deaf ears! We have to do something. What do you suggest then?

Decision-maker (you)

A The best thing that we can do is organise a process mapping session with everyone involved.

B We need more data so we can wait for the first sign of improvement and then capture this and implement change.

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Project support officer

All of my ideas seem to be falling on deaf ears! We have to do something. What do you suggest then?

Decision-maker (you)

(A) **The best thing that we can do is organise a process mapping session with everyone involved.**

(B) We need more data so we can wait for the first sign of improvement and then capture this and implement change.

Suggested answer A

The best thing that we can do is organise a process mapping session with everyone involved… We can then agree some change ideas and put in place measures to track whether they result in improvement.

#plotthedots

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Scenarios for decision-makers

Scenario 2: Target setting

You are attending a target setting meeting with commissioners to agree next year's trajectories for the outreach service. The commissioners would like their investment realised with the service used as much as possible, and are keen to set a trust a high target to encourage its delivery of the service.

The meeting starts with the commissioners reviewing how many new referrals the outpatient clinic has received in the last financial year. They have added a linear forecast line.

Outpatient clinic: new referrals

Follow this conversation and think about how you would respond now compared with how you would have done in the past.

Commissioning analyst

I've drawn a linear trend line against last year's referrals; it shows an upward trajectory from around 70 to 90 new referrals per month. I propose we set next year's target for the service at a minimum of 90 referrals per month.

Decision-maker (you)

A That's a fair target. We're already on 90 from the trend line. Extending this line forward we should push beyond 80 easily.

B Can we look at this data differently? My experience is that linear trend lines can be misleading.

Commissioning analyst

I've drawn a linear trend line against last year's referrals; it shows an upward trajectory from around 70 to 90 new referrals per month. I propose we set next year's target for the service at a minimum of 90 referrals per month.

Decision-maker (you)

A That's a fair target. We're already on 90 from the trend line. Extending this line forward we should push beyond 80 easily.

B Can we look at this data differently? My experience is that linear trend lines can be misleading.

Suggested answer B

Can we look at this data differently? My experience is that linear trend lines can be misleading... Linear trend lines are by nature straight lines which give the impression of constant improvement or decline. I'd like to investigate the variation in this system.

Commissioning analyst

What do you suggest?

Decision-maker (you)

A I'd like to draw a SPC chart so we can understand the variation and make a better estimate of how many referrals we can expect to receive each month.

B Let's extend the dataset to 24 months; this will base the trend line on more data and give us a more reliable forecast.

Commissioning analyst

What do you suggest?

Decision-maker (you)

A I'd like to draw a SPC chart so we can understand the variation and make a better estimate of how many referrals we can expect to receive each month.

B Let's extend the dataset to 24 months; this will base the trend line on more data and give us a more reliable forecast.

Suggested answer B

I'd like to draw a SPC chart so we can understand the variation and appreciate how many referrals we can expect to receive each month. I'll use 24 months of data as this will provide a more robust answer.

Commissioning analyst

I'm not sure SPC is relevant for target setting, but I agree that looking at 24 months would be useful. Let's both go away and compare our analysis at the next meeting.

Decision-maker (you)

You ask your analyst to create a SPC chart (see next page) and take it along to the next meeting.

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Outreach service: new referrals

Outreach service: new referrals

Commissioning analyst

My linear trend line still shows an upward trajectory ending at around 90. What does your SPC chart show?

Decision-maker (you)

A The SPC chart shows that we can expect between 30 and 122 referrals each month.

B We're on an upward trend and the target line of 90 is well within the upper process limit, so this target is well within our trajectory.

Commissioning analyst

My linear trend line still shows an upward trajectory ending at around 90. What does your SPC chart show?

Decision-maker (you)

A The SPC chart shows that we can expect between 30 and 122 referrals each month.

B We're on an upward trend and the target line of 90 is well within the upper process limit, so this target is well within our trajectory.

Suggested answer A

The SPC chart shows that we can expect between 30 and 122 referrals each month. If the target is set at 90 it will be achieved or missed due to random variation. There is a lot of variation in the system. We should focus on understanding why this is and then look to minimise the variation as this will make it much easier to plan the service. Then we can look at setting a realistic target.

Tools and approaches to support better decision-making

Mark Outhwaite, Non Executive Director, AWP NHS Trust, talks about the importance of asking the right questions, having the right data and having the capacity and capability to analyse and act. He describes how the use of SPC can support more effective capacity and demand planning and target redesign efforts.

Before you watch Mark's video think about your own approaches to asking analytical questions, how you use the data you already have and how you interact with your analysts. What would you do?

After you have watched Mark's video, think about whether the approach his organisation has taken could help influence your own practice.

We're working with an increasing number of trusts that are abandoning traditional RAG reports with two-point comparisons and instead plotting data as SPC charts. We're working with a number of trusts to explore how we can best use commentary and icons to ensure that messages from the data are clear and simple – to guide decision-makers to the best course of action. Here's an example showing how Avon and Wiltshire Mental Health Partnership NHS Trust has changed its reporting.

Here's a useful paper published in 2016. It looks at the type of analysis presented in trust board papers and how rarely normal variation and chance are considered.

Considering chance in quality and safety performance measures: an analysis of performance reports by boards in English NHS trusts

Any non-executive directors reading this guide may be interested in:

Quality improvement and measurement – what non-executive directors need to know

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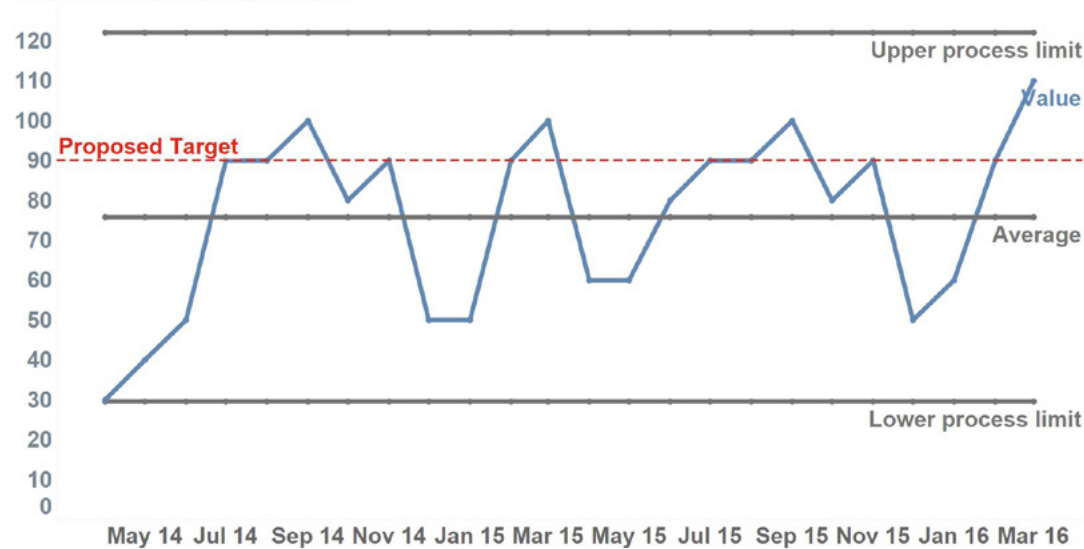
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Take some time to think about on what you have learnt from this section and how this applies to the issues you come up against every day. Discuss these with your team and together think about how you could use data more effectively to help solve those problems. **Printout the table below** and try using the 3-2-1 structure to order your thoughts.

3	Things that you have learnt that could make your role as a decision-maker easier
2	'Ah ha!' moments…
1	Immediate next action towards using data for better judgement and decision-making…

Share a picture of your completed 3-2-1 template or your one action with us via Twitter using **#plotthedots**

Take a bit of time to think about your relationship with your analytical team. Do you know where they are based? Many organisations have individual analysts assigned to specific services or directorates; is this the case for your area of work?

We know that simply setting a target does little to change how a process or system performs. Measurement and monitoring must be accompanied by action if system change is to be achieved.

These two scenarios demonstrate how understanding variation can help describe the capability, and to some extent, the reliability of a process in meeting a target. A visual presentation of the variation is useful when setting strategic goals – it shows you what is, and as importantly what is not, achievable.

What next?

This section has outlined some of the practical benefits and challenges of adopting analytical approaches that support better judgement and decisions for action. Do revisit this section whenever you need to; follow the links to guidance and resources, get some inspiration from our experts or retake the six-point self-assessment checklist at the beginning to see how your organisation is progressing with the **#plotthedots** ethos.

Here are some practical actions that you can take now:

- Take **our quiz** to test your knowledge.

- Search out your analysts – invite them along to operational meetings.

- When you are asked to produce an action plan, consider whether this is the best course of action.

- Have a look at the next analysis you receive and think about how it could be more useful.

- Organise an education session for colleagues to explain the benefits of SPC over RAG.

find quiz here

?

Get involved!

Share your experiences on Twitter using **#plotthedots** and join our virtual community of interest for everyone striving to improve their use of data – currently we have nearly 800 members. As well as the opportunity to link up with #plotthedots fans, this will give you access to a wealth of resources and toolkits to make better use of data.

Email **nhsi.improvementanalyticsteam@nhs.net** if you would like to join.

Think about what **you** can do to encourage better use of data for judgement and decisions for action and make a pledge.

Go to template

I pledge to...

Write your pledge and share it on Twitter using **#plotthedots**

Doing it together:
Plotting dots – putting new knowledge into practice

So far we've talked about the problems and challenges faced by analysts and decision-makers separately, and provided some useful resources and exercises to get each of these groups thinking about actions and changes they can make in their organisations.

Hopefully this is useful in itself, but real change comes with a collaborative approach, pooling expertise and skills, opinions and ideas to develop critical insight.

Collaboration stems from the simple act of sitting down together and discussing data. What it means to each of you, what you'd like to know next, what is practically possible; the list of questions is endless, but only by having a conversation will they be properly explored.

Right, let's do it then, analysts and decision-makers working together, right here, right now.

Well, go on then, go find your analyst or decision-maker.

Come back with a cuppa once you've introduced yourselves.

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Look at this data and have a chat about what it tells you, what it doesn't tell you and what action you would take as a result of looking at it. Have you changed your view as a result of working through this guide? How might you prefer the data to be presented?

Operational performance

NHS Improvement dashboard

	Key Performance Indicator	Target	2016-7					2017-8							Charge
			Q3	Q4				Q1			Q2			Q3	
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Access	7 day follow-up to discharge	95%	96.7%	96.7%	96.4%	96%	96.7%	97.1%	97.6%	97.4%	97.3%	97.4%	97.3%	97.4%	▲
	Service users with review (CPA)	95%	97%	97.2%	97%	96.9%	97.2%	97.3%	97.9%	97.8%	97.6%	96.6%	96.6%	96.2%	▼
	EI referral to treatment	50%	70.4%	78.4%	86.8%	83.3%	82.7%	78.5%	93.1%	83.3%	80.6%	76.4%	83.7%	84.6%	▲
	IAPT - waiting times (6 weeks)	75%	94.2%	96.5%	95.6%	94.9%	96.3%	95.6%	94.9%	94.7%	95.4%	95.5%	95.3%	96.7%	▲
	IAPT - waiting times (18 weeks)	95%	100%	99.9%	99.6%	99.7%	100%	99.8%	99.8%	100%	99.8%	99.4%	99.7%	99.7%	▲
	Gate keeping - intensive	95%	97.5%	98.5%	98.6%	99%	99%	98.5%	98.1%	96.4%	96.8%	96.8%	98.9%	97.5%	▼
Outcomes	DTOC	<=7.5%	11.3%	11.9%	11.8%	11.6%	12.1%	13.3%	14.3%	14.1%	13.3%	11.7%	10.4%	9.3%	▲
	Data quality: outcomes	50%	85.7%	86%	85.5%	85.7%	85.2%	85.2%	84.7%	83.7%	83.7%	85.5%	86.3%	87.5%	▲
	Data quality: Identifiers	97%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	▲
CQC	CQC judgements	Green											✔	✔	◆
	Number of concerns raised		2	2	2	2	2	2	2	2	2	2	1	1	

A concern is raised for each indicator below target for nine or more months in a row.

Here's a SPC chart that plots the number of cases 'between surgical site infections'; that is, the number of surgeries that were infection free before the next case of surgical infection. Each dot represents a surgical site infection. Thankfully surgical site infection is pretty rare, but when it happens the consequences can be very serious for patients, the surgical and medical teams treating them and, in financial and reputational terms, the organisation.
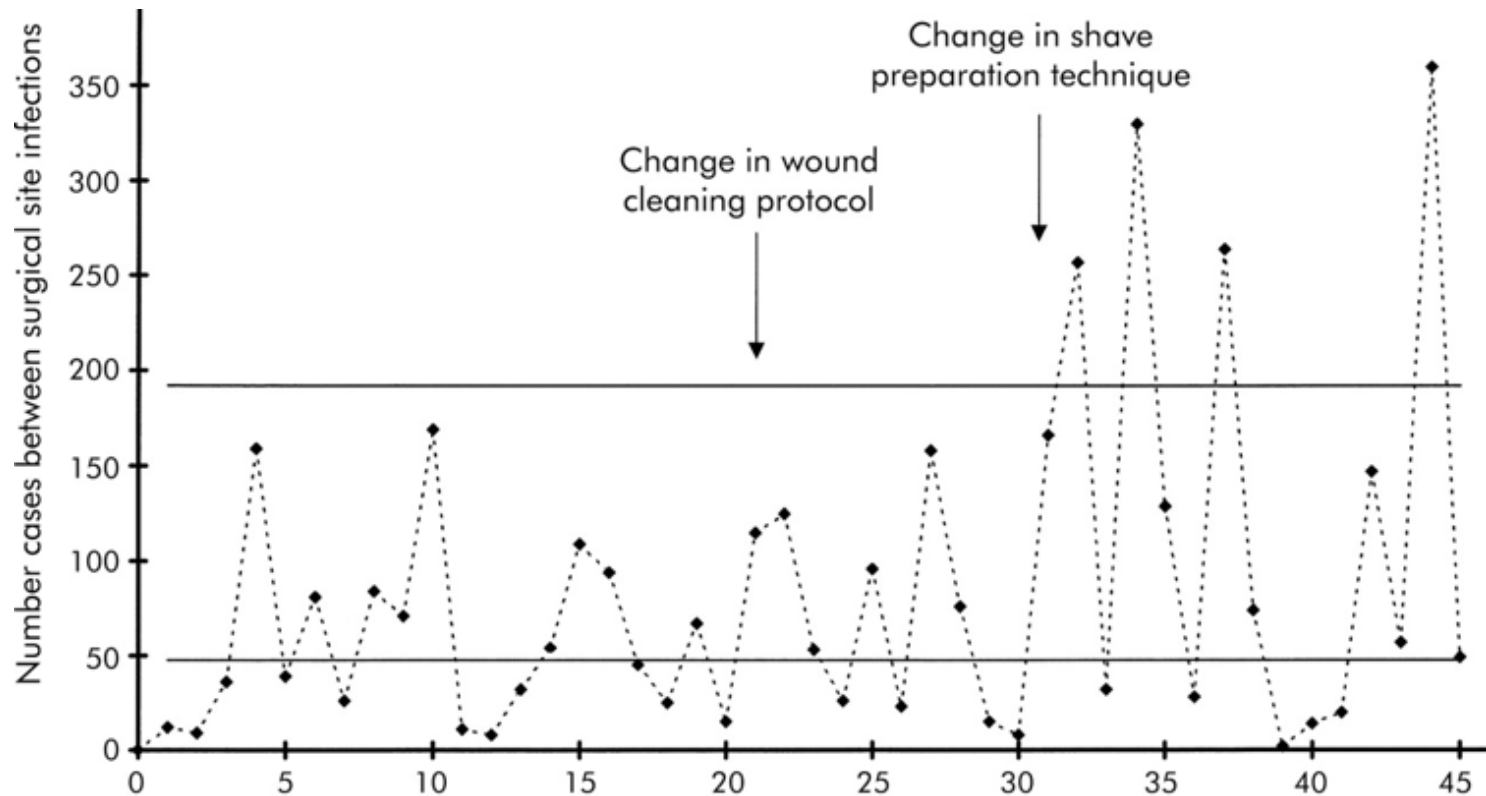
Chart from Benneyan et al., 2003

Spend two minutes looking at this chart on your own and jot down the following:

- a sentence summarising what the chart tells you

- the action you would take based on this chart.

Don't speak to each other.

Now compare answers. Do you agree?
Did you note things that others didn't?

We asked two analysts, an ops manager and
an orthopaedic registrar to do this exercise.
They came up with the following nuggets…

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If you take just one learning point from this guide it should be the value of collaboration between analytical expertise and decision-making know-how.
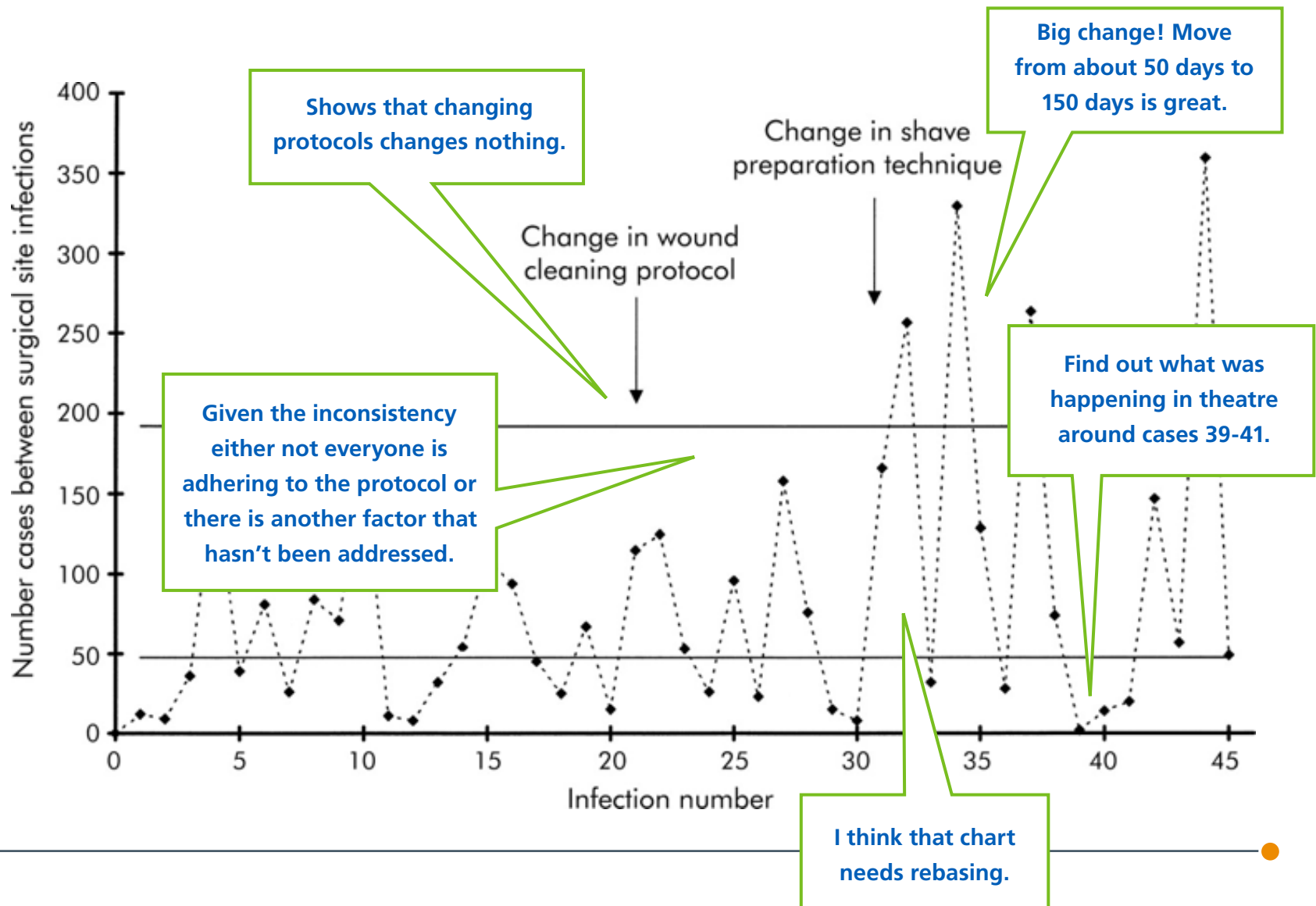
Shows that changing protocols changes nothing.

Change in wound cleaning protocol

Change in shave preparation technique

Big change! Move from about 50 days to 150 days is great.

Given the inconsistency either not everyone is adhering to the protocol or there is another factor that hasn't been addressed.

Find out what was happening in theatre around cases 39-41.

I think that chart needs rebasing.

Train the trainer:
Group exercises

We find in many of the organisations we work with that a small handful of individuals hold most of the knowledge about using data for better judgement and decisions for action.

If this describes your organisation this section provides exercises you can run with your teams to widen understanding of the fundamental principles that underpin measuring variation over time. Feel free to print these pages off or show the videos; they're suitable for medium to large groups with no previous understanding of statistics or SPC.

The resources and videos we've linked to so far will also help you.

If you find these exercises useful, send us a picture of your team and tweet about your experience using **#plotthedots**
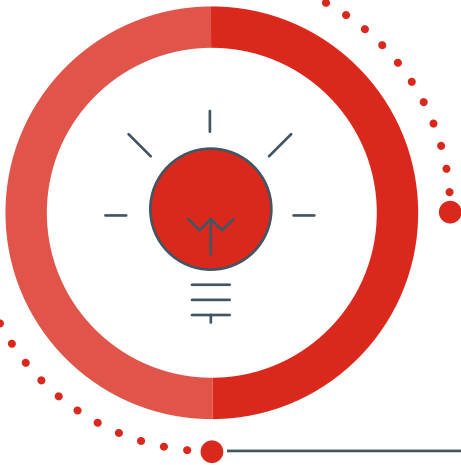
Exercise 1: Understanding probability

Learning aims

- To show that people intuitively know when things are unusual.

- To explain the problem with using two-point comparisons to inform action.

- To explain the principles behind some of the rules that are used to identify special cause variation.

Activity

1. Before you start, nominate a person to be your 'caller' and out of earshot of the rest tell them to call 'heads' every time, ignoring how the coin actually lands.

2. Show the team this example of a two-point comparison bar chart and ask them what their response would be; record these to refer to later.

Two-point comparison
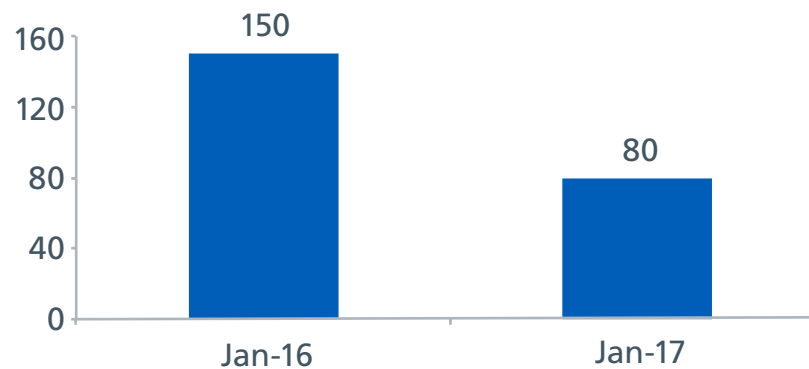
3. Flip a coin 10 times and get your 'caller' to call each flip (the caller should call heads each time). After each flip, ask everyone in the room to record their thoughts about what is happening. You'll be lying when you confirm the 'caller' was correct each time. This step can be as melodramatic as you like!

4. It's likely that with more and more coin flips and the same result – heads – the team will get more questioning of the result. After 10 flips have been called heads, ask the team what they thought was happening.

Explanation

- Confess that you were lying (assuming someone accused you!) and think about the behaviour in the room and the feedback from individuals. Instinctively they will think something very unlikely was happening; the chances of getting 10 'heads' in a row is less than one-tenth of a percentage point (1 in 1,024).

- Ask the team why they didn't question two 'heads' in a row (25% chance, 1 in 4), or three 'heads' in a row (12.5% chance, 1 in 8). They will probably say this was because the occurrence of both series felt likely or possible.

- Referring back to the earlier responses to the two-point comparison bar chart, suggest to the team that responding to just two points is equivalent to reacting to someone flipping two heads in a row.

- When we look at data over time to understand variation, we often use rules to define whether something unusual (special cause) has occurred; one of these is a run of consecutive points above or below the centre line – but there is often contention over how many consecutive points 'count' as special cause.

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- Using our coin toss analogy, a point above the centre line could be viewed as a 'head' and each point below it a 'tail'. A series of eight consecutive points above the centre line would be equivalent to flipping eight heads in a row with odds of 1 in 256.

Coin flipping
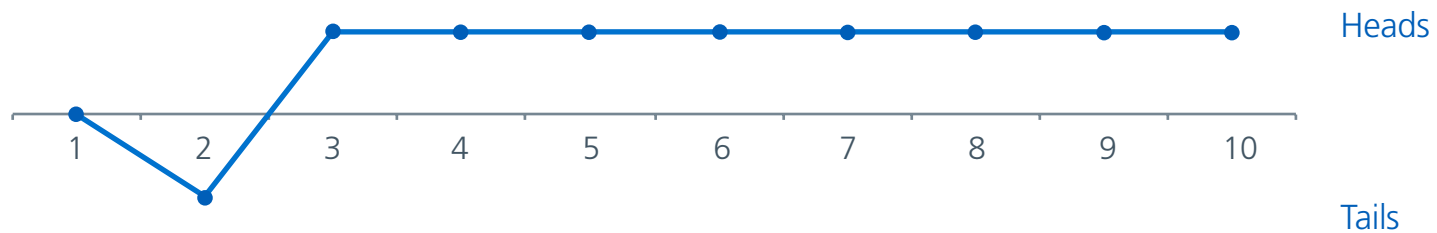
- The number of consecutive points you choose to consider 'unusual' depends on the degree of probability you are comfortable with in the context in which you are measuring. At what point does the probability become so small that you concede something unusual is happening? When we did this exercise, participants were ready to accuse us of cheating by coin flip 6 (1 in 64 odds) or 7 (1 in 128 odds).

Exercise 2: SPC in practice

Learning aims

- To understand how SPC can be used to understand variation.

- To understand that common cause variation is due to random chance.

Activity

- Download the SPC template **here** and show it to the group.

- **Watch this video** – either play along with Tom Nicholas or replicate the game yourself.

- You can run an alternative version of this game using an **online random number generator**. This works well for large groups

Random variation – a game

Thomas Nicholas, Senior Information Analyst, NHS Improvement, takes us through a game you can play with a group of any size to help illustrate the importance of understanding random variation. He explains how systems can randomly generate data that looks like a signal and how a tool like SPC is critical in interpreting variation appropriately.

Explanation

- In any set of numbers some will be higher than others. This is normally the result of random chance.

- Plotting numbers over time provides a better insight into this randomness and understanding of what is 'normal' in the systems and processes in which we operate.

Exercise 3: Learning about variation by counting sweets!
(from the Institute for Healthcare Improvement)

Learning aims

- To define common cause variation and special cause variation.

- To discuss why knowledge of variation is important when working to improve a process or system.

Activity

- Before you start you'll need to give a small bag of M&Ms (or similar) to each person in the group and a couple of bigger bags to one or two individuals. Prepare a simple run chart to view on screen with participant number on the x-axis and number of M&Ms on the y-axis.

- Get each group member to open their bag of sweets and count them (no eating!).

- In turn get each group member to call out the number of M&Ms in their bag and plot these sequentially on the prepared run chart.

- Once you've collected all the data, eat the sweets!

Explanation

This video covers what can be learned from this exercise and discusses why knowledge of variation is important when trying to change a process or system.

You may also wish to discuss the following points with the group to put the learning points into your own context:

1. Think of a work process you're familiar with. What would be an example of common cause and special cause variation in this process?

2. Why is understanding variation useful when you are trying to improve a process or system?

3. Imagine you're working on an improvement project and you notice a data point that's far outside the normal range of variation. What would be your first course of action?

Watch the video for more detail on this exercise.

Make your pledge

Hopefully you're as passionate as we are about changing the way we use the wealth of data available to support better judgement and decisions for action.

To build momentum we're asking both analysts and decision-makers to make a pledge to support and take action to make better use of data the norm across the NHS.

Join Adam Sewell-Jones and your colleagues in making this pledge to improve the use of data.

I pledge to...

Go to template

Write down your pledge for action, take a picture of it and tweet it using **#plotthedots**

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If you're stuck for a pledge, here are few ideas

When I see a two-point comparison I will ask to see the rest of the data.

Next time I receive data about our performance I will have a conversation about it.

I will go and find my analytical team (and take them biscuits / cake / Star Wars merchandise).

When I see a RAG status table I will ask to see the previous trends.

Before I set a target I will look at the capability of the process on which it relies.

Resources

Model for improvement

Langley GJ, Nolan KM, Norman CL, Provost LP, Nolan TW. *The improvement guide: a practical approach to enhancing organizational performance*, second edition. Wiley Desktop Editions, 2009.

Davidge M. Measurement for improvement 10 minute video. www.youtube.com/watch?v=Za1o77jAnbw
This gives a useful overview of seven steps to measurement for improvement.

Measurement

Solberg L, Mosser G, McDonald S. *The three faces of performance measurement: improvement, accountability, and research. Jt Comm J Qual Improv* 1997;23(3):135–47.

Raleigh VS, Foot C. *Getting the measure of quality: opportunities and challenges*. London: King's Fund, 2010.
This is a comprehensive overview of measuring quality, the different types of measurement and approaches.

Rosling H, Rosling O, Rosling Rönnlund A. *Factfulness: Ten Reasons We're Wrong About the World – and Why Things Are Better Than You Think*. Sceptre. 2018.

Visualising data

Smith JM. *Meaningful graphs: converting data into meaningful Excel charts*. James M Smith, 2014.
The book guides you through displaying data using Excel.

Rosling H. Hans Rosing shows the best stats you've ever seen, 2006.
https://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen
This video demonstrates the power of strong visual display of data (world development focus).

Nussbaumer Knaflic C. *Storytelling with Data: A Data Visualization Guide for Business Professionals.* John Wiley & Sons Inc, 2015. This book teaches you the fundamentals of data visualization and how to communicate effectively with data.

Mohammed MA, Cheng K, Rouse A, Marshal T. *Lessons from variation with case studies from health care, including Bristol & Shipman, 2001.* https://www.cem.org/attachments/ebe/P193-202%20Mohammed%20Mohammed%20et%20al.pdf

Variation and statistical process control (SPC)

Wheeler D. *Understanding variation – the key to managing chaos*, second edition. Knoxville: SPC Press, 2000. This is a great introduction to variation and SPC.

Wheeler D. *Making sense of data, SPC for the service sector.* Knoxville: SPC Press, 2003. This tells you all you ever wanted to know about control charts.

Perla R, Provost L, Murray S. *The run chart: a simple analytical tool for learning from variation in healthcare processes. BMJ Qual Saf* 2011;20:46e51. doi:10.1136/bmjqs. 2009.037895. This provides an introduction to run charts.

Nelson L. *The Shewhart control chart – tests for special causes, technical aids. J Qual Technol* 1984;16:238–239. This gives control chart rules.

NHS England. *Demand and Capacity.* https://www.england.nhs.uk/ourwork/demand-and-capacity/

Improvement and leadership

Developing People – Improving Care: A national framework for action on improvement and leadership development in NHS-funded services. National Improvement and Leadership Development Board, 2016. https://improvement.nhs.uk/resources/developing-people-improving-care/

Developing People - Improving Care Together: one year on. National Improvement and Leadership Development Board, 2018. https://improvement.nhs.uk/resources/developing-people-improving-care-one-year/

Anhøj J, Hellesøe AB. *The problem with red, amber, green: the need to avoid distraction by random variation in organisational performance measures. BMJ Qual Saf* 2017;26:81–84. http://qualitysafety.bmj.com/content/26/1/81

Mountford J, Wakefield D. *From stoplight reports to time series: equipping boards and leadership teams to drive better decisions. BMJ Qual Saf* 2017;26:9–11. http://qualitysafety.bmj.com/content/26/1/9

Quality improvement and measurement: what non executive directors need to know. Scottish Government, 2016. http://www.gov.scot/Resource/0049/00492311.pdf

Schmidtke KA, Poots AJ, Carpio J et al. *Considering chance in quality and safety performance measures: an analysis of performance reports by boards in English NHS trusts. BMJ Qual Saf* 2017;26:61–69. http://qualitysafety.bmj.com/content/26/1/61

Improving quality

Benneyan JC, Lloyd RC, Plsek PE. *Statistical process control as a tool for research and healthcare improvement. BMJ Qual Saf* 2003;12:458–464.

Mohammed MA. *Using statistical process control to improve the quality of health care. BMJ Qual Saf* 2004;13:243–245.

Offord N, Harriman P, Downes T. *Discharge to assess: transforming the discharge process of frail older patients. Future Hosp J* 2017;4(1):30–32.

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Tools you can use

SPC tool link.

This is a SPC template developed by NHS Improvement which you can use to make and annotate your own SPC chart.

Delayed transfer of care (DToC) improvement tool

This tool has been developed to enable trusts, clinical commissioning groups and local authorities to understand where delayed transfers of care are in their area or system.

Emergency flow improvement tool

If you work in a NHS trust you can access the tool via the emergency medicine section of the Model Hospital website at model.nhs.uk. Others can request access by emailing NHSI.efit@nhs.net. This online tool helps trusts view patient flow from arrival to discharge.

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Useful websites/blogs

www.davisdatasanity.com

Davis Balestracci is an experienced improvement practitioner and statistician who makes data an enjoyable read!

www.kurtosis.co.uk

Neil Pettinger is an information manager by background and covers a range of topics around data analysis and presentation.

www.staceybarr.com

Stacey Barr is an Australian with a background in performance measurement so really speaks to those who think KPIs are the be-all and end-all.

NHS Improvement Advancing Change Team

ACT Academy's Quality, Service Improvement and Redesign (QSIR) programmes enable organisations and systems to build sustainable service improvement capability. They include a measurement module that incorporates how to construct and use statistical process control and run charts. QSIR is an improvement methodology developed by the NHS, for the NHS, to create a culture of change and improvement across health and care.

For information on how to apply and key dates, please see the QSIR programme webpage https://improvement.nhs.uk/resources/qsir-programme/

Making data count playlist

https://www.youtube.com/playlist?list=PLHpuGzxwIagxaIseuF1iNqiPkxeq6dlxa

Here you can find the whole collection of videos contained within this guide.

Acknowledgements

Glossary

Term	Definition
Centre reference line	The average line (often represented by the mean, sometimes the median)
Common cause variation	Periodic changes in the data that are predictable and expected
Control limits	Two lines, one above and one below the average line, which define the variation of the dataset. Also known as process limits
Linear trend line	A best fit straight line drawn onto charts to indicate something that is increasing or decreasing at a steady rate
Lower process limit	The line below the average line (mean), which defines the lower boundary of expected variation
Mean line	Represents the arithmetic average data plotted on the chart
Median line	Represents the middle number in the data plotted on the chart
Natural variation	See common cause variation
Process limits	See control limits
Process mapping	Enables you to create a visual picture of how the system currently works
RAG approach	Categorising data using 'red, amber, green' based on targets

Random variation	See common cause variation
Rebasing	Redrawing the reference lines on the chart to reflect a change in the system
Reference lines	Represent the upper and lower process limits and mean or median line. Overlaid on the recorded data line
Special cause variation	Changes in the data that are unpredictable and unexpected
Statistical process control	A method to support the robust statistical interpretation of measures presented over time and to understand if your process has special cause and/or common cause variation
Times series	Values of a quantity obtained at successive times, often with equal intervals between them
Upper and lower reference lines	Process limits, see control limits
Upper process limit	The line above the average line (mean), which defines the upper boundary of expected variation
Variation	A change or slight difference in the data, typically within certain limits
XmR chart	The XmR chart has two parts. The X-chart displays the data points over time together with a calculated average. The calculated average is then used to calculate the upper and lower process limits

The moving range (mR) chart shows the difference between consecutive observations and is recorded as a positive number. The average is displayed and then used to calculate the upper process limit |

Quiz

Start here ▶

1 The definition of spuddling is:

A To have fun jumping around in puddles.

B To make a lot of fuss about trivial things as if they were important.

C To confuse the order of words in a sentence.

D There isn't one – it isn't a real word.

reveal answer ▶

1 The definition of spuddling is:

A. To have fun jumping around in puddles.

B. **To make a lot of fuss about trivial things as if they were important.**

C. To confuse the order of words in a sentence.

D. There isn't one – it isn't a real word.

2 What conclusions can you draw from the following chart?
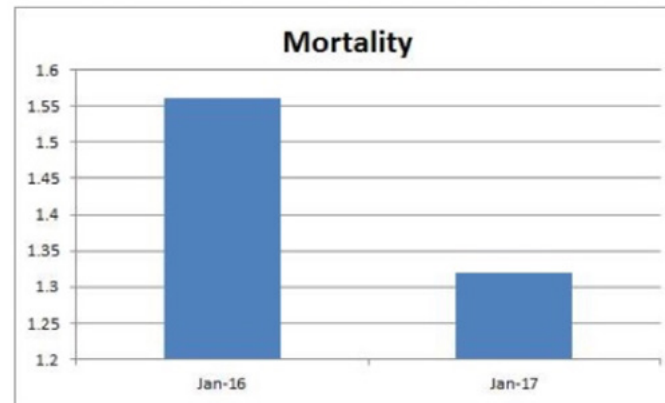
A The mortality rate has improved over the year.

B The mortality rate has got worse over the year.

C The mortality rate is different in January 2017 compared to January 2016.

D There is no difference in the mortality rate.

reveal answer ▶

2

What conclusions can you draw from the following chart?
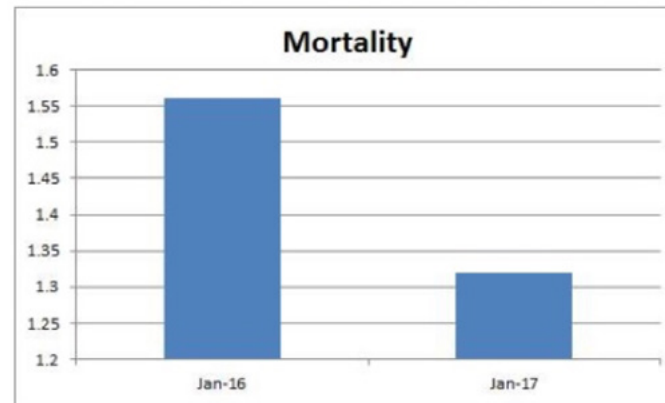
A The mortality rate has improved over the year.

B The mortality rate has got worse over the year.

C **The mortality rate is different in January 2017 compared to January 2016.**

D There is no difference in the mortality rate.

3 When thinking about which SPC rules I should use, I should consider:

A It doesn't matter which rules I use.

B What level of risk I am comfortable with?

C Whether all of the available SPC rules are relevant to my dataset.

D Those which stop me going down dead ends.

reveal answers ▶

3

When thinking about which SPC rules I should use, I should consider:

A It doesn't matter which rules I use.

B What level of risk I am comfortable with?

C Whether all of the available SPC rules are relevant to my dataset.

D Those which stop me going down dead ends.

4 SPC charts can be used to understand:

A Whether changes made have resulted in improvement.

B Whether it is likely that a performance target can be sustainably met.

C The level of variation in a system.

reveal answers ▶

4

SPC charts can be used to understand:

A Whether changes made have resulted in improvement.

B Whether it is likely that a performance target can be sustainably met.

C The level of variation in a system.

5

If I see a SPC chart that is in control and shows no special cause variation, I should:

A Do nothing – my job here is done!

B Panic.

C Consider whether the level of variation is acceptable.

D Plan a process mapping session to understand my process.

reveal answers ▶

5

If I see a SPC chart that is in control and shows no special cause variation, I should:

A Do nothing – my job here is done!

B Panic.

C Consider whether the level of variation is acceptable.

D Plan a process mapping session to understand my process.

6

Having read this document I should:

A Share what I have learnt.

B Create a SPC chart.

C Run an education session for colleagues explaining the benefits of SPC over RAG.

D Identify one or more SPC champions.

E Think about how to ensure that analysts and decision-makers are connected.

F Encourage people to join the SPC virtual community.

reveal answers ▶

6   **Having read this document I should:**

A   Share what I have learnt.

B   Create a SPC chart.

C   Run an education session for colleagues explaining the benefits of SPC over RAG.

D   Identify one or more SPC champions.

E   Think about how to ensure that analysts and decision-makers are connected.

F   Encourage people to join the SPC virtual community.

What should I think/ask when presented with this type of data?

	Key Performance Indicator	Target	2016-7					2017-8						Charge
			Q3		Q4			Q1			Q2		Q3	
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Access	7 day follow-up to discharge	95%	96.7%	96.7%	96.4%	96%	96.7%	97.1%	97.6%	97.4%	97.3%	97.4%	97.3%	97.4%	▲
	Service users with review (CPA)	95%	97%	97.2%	97%	96.9%	97.2%	97.3%	97.9%	97.8%	97.6%	96.6%	96.6%	96.2%	▼
	EI referral to treatment	50%	70.4%	78.4%	86.8%	83.3%	82.7%	78.5%	93.1%	83.3%	80.6%	76.4%	83.7%	84.6%	▲
	IAPT - waiting times (6 weeks)	75%	94.2%	96.5%	95.6%	94.9%	96.3%	95.6%	94.9%	94.7%	95.4%	95.5%	95.3%	96.7%	▲
	IAPT - waiting times (18 weeks)	95%	100%	99.9%	99.6%	99.7%	100%	99.8%	99.8%	100%	99.8%	99.4%	99.7%	99.7%	▲
	Gate keeping - intensive	95%	97.5%	98.5%	98.6%	99%	99%	98.5%	98.1%	96.4%	96.8%	96.8%	98.9%	97.5%	▼
Outcomes	DTOC	<=7.5%	11.3%	11.9%	11.8%	11.6%	12.1%	13.3%	14.3%	14.1%	13.3%	11.7%	10.4%	9.3%	▲
	Data quality: outcomes	50%	85.7%	86%	85.5%	85.7%	85.2%	85.2%	84.7%	83.7%	83.7%	85.5%	86.3%	87.5%	▲
	Data quality: Identifiers	97%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	▲
CQC	CQC judgements	Green											✓	✓	◀▶
	Number of concerns raised		2	2	2	2	2	2	2	2	2	2	1	1	

A I only need to worry about the reds.

B Is there a more meaningful way to look at this data?

C Can you show me some SPC charts instead?

D The manager of DToC needs to be sacked.

reveal answer(s) ▶

What should I think/ask when presented with this type of data?

	Key Performance Indicator	Target	2016-7					2017-8						Charge
			Q3		Q4			Q1			Q2		Q3	
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Access	7 day follow-up to discharge	95%	96.7%	96.7%	96.4%	96%	96.7%	97.1%	97.6%	97.4%	97.3%	97.4%	97.3%	97.4%	▲
	Service users with review (CPA)	95%	97%	97.2%	97%	96.9%	97.2%	97.3%	97.9%	97.8%	97.6%	96.6%	96.6%	96.2%	▼
	EI referral to treatment	50%	70.4%	78.4%	86.8%	83.3%	82.7%	78.5%	93.1%	83.3%	80.6%	76.4%	83.7%	84.6%	▲
	IAPT - waiting times (6 weeks)	75%	94.2%	96.5%	95.6%	94.9%	96.3%	95.6%	94.9%	94.7%	95.4%	95.5%	95.3%	96.7%	▲
	IAPT - waiting times (18 weeks)	95%	100%	99.9%	99.6%	99.7%	100%	99.8%	99.8%	100%	99.8%	99.4%	99.7%	99.7%	▲
	Gate keeping - intensive	95%	97.5%	98.5%	98.6%	99%	99%	98.5%	98.1%	96.4%	96.8%	96.8%	98.9%	97.5%	▼
Outcomes	DTOC	<=7.5%	11.3%	11.9%	11.8%	11.6%	12.1%	13.3%	14.3%	14.1%	13.3%	11.7%	10.4%	9.3%	▲
	Data quality: outcomes	50%	85.7%	86%	85.5%	85.7%	85.2%	85.2%	84.7%	83.7%	83.7%	85.5%	86.3%	87.5%	▲
	Data quality: Identifiers	97%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%	▲
CQC	CQC judgements	Green											✔	✔	◆
	Number of concerns raised		2	2	2	2	2	2	2	2	2	2	1	1	

A I only need to worry about the reds.

B Is there a more meaningful way to look at this data?

C Can you show me some SPC charts instead?

D The manager of DToC needs to be sacked.

8

Pitfalls that I need to be wary of on my RAG to SPC journey are:

A Plotting the dots and taking no action.

B Assuming people will understand the charts.

C Being aware that some people will retain two-point comparison thinking when looking at a SPC chart.

reveal answer(s) ▶

8

Pitfalls that I need to be wary of on my RAG to SPC journey are:

A   Plotting the dots and taking no action.

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C   Being aware that some people will retain two-point comparison thinking when looking at a SPC chart.

9

By joining the measurement for improvement community of interest I will be able to access:

A The wisdom of nearly 800 people interested in measuring better.

B Published papers on the benefits of using control charts.

C Measurement templates and tools.

D Guides on how to measure better.

reveal answer(s) ▶

9

By joining the measurement for improvement community of interest I will be able to access:

A   The wisdom of nearly 800 people interested in measuring better.

B   Published papers on the benefits of using control charts.

C   Measurement templates and tools.

D   Guides on how to measure better.

Performance table	Target	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017	Aug 2017
Metric 1	50	100	100	83	100	100	100	100	67
Metric 2	75	86	84	82	82	75	80	81	81
Metric 3	95	100	99	100	100	100	100	100	100
Metric 4	50	57	57	54	56	53	52	55	55

Key performance indicator dashboard
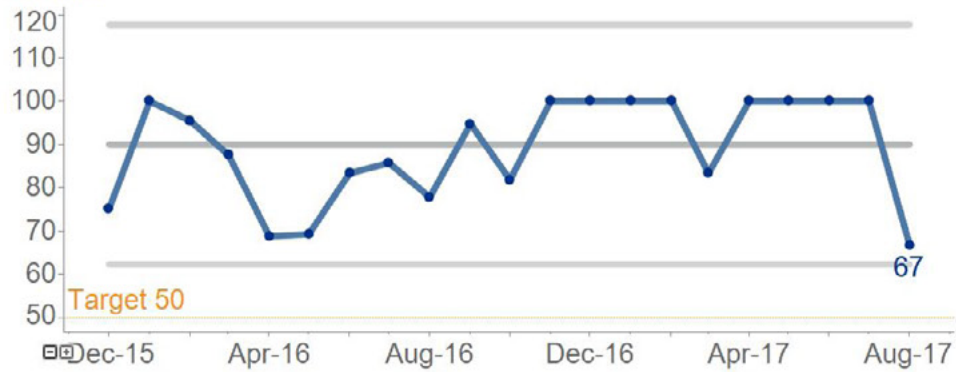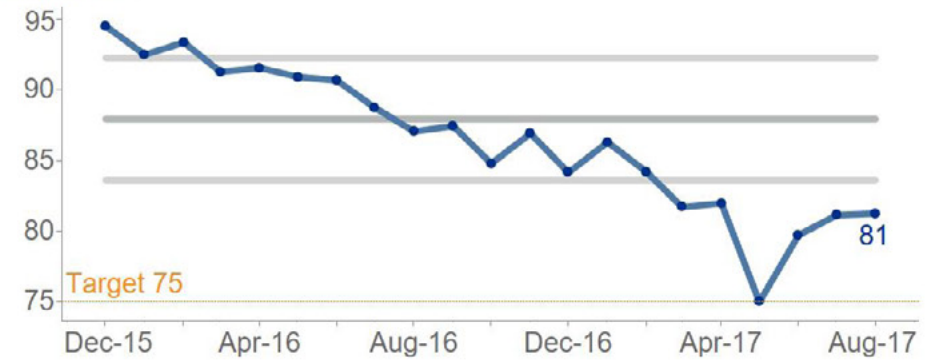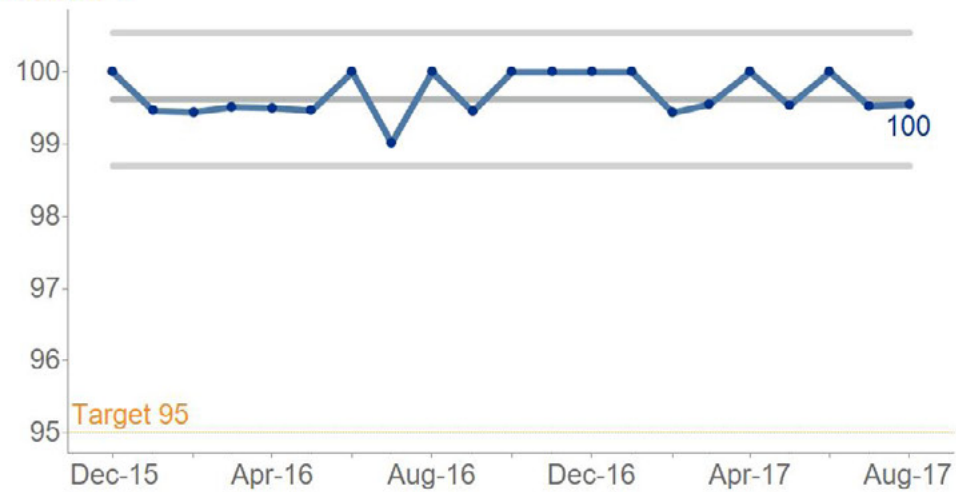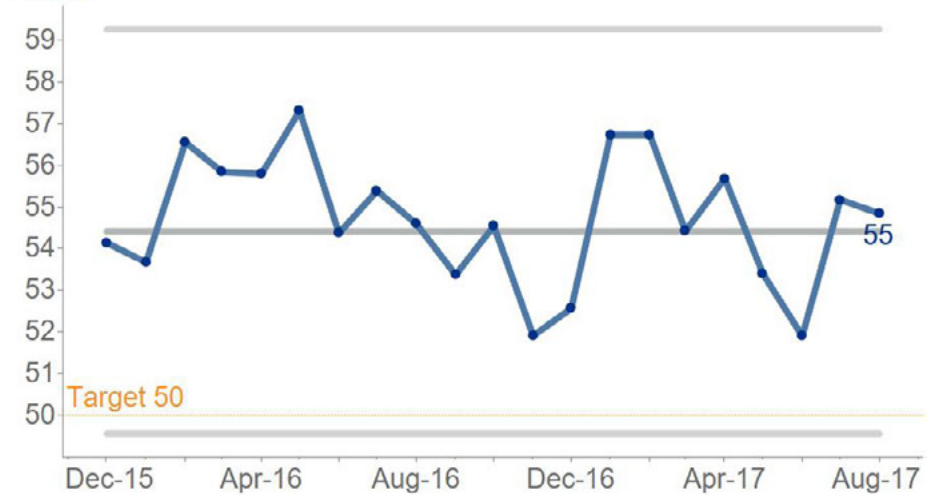
Key performance indicator	Target	Apr	May	Jun	Jul	Aug	
Gate-keeping of admissions by crisis teams	95%	98%	98%	96%	97%	97%	▲
Delayed transfer of care	7.5%	13%	14%	15%	13%	12%	▼

Gate-keeping of admissions by crisis teams
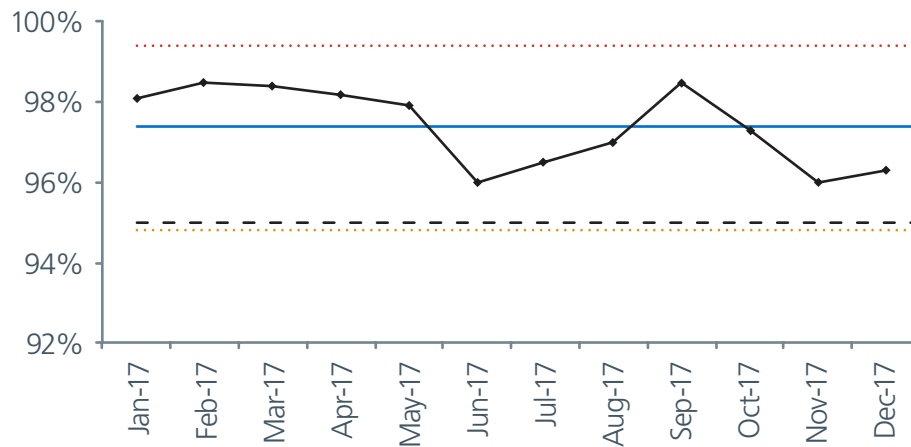
Delayed transfer of care
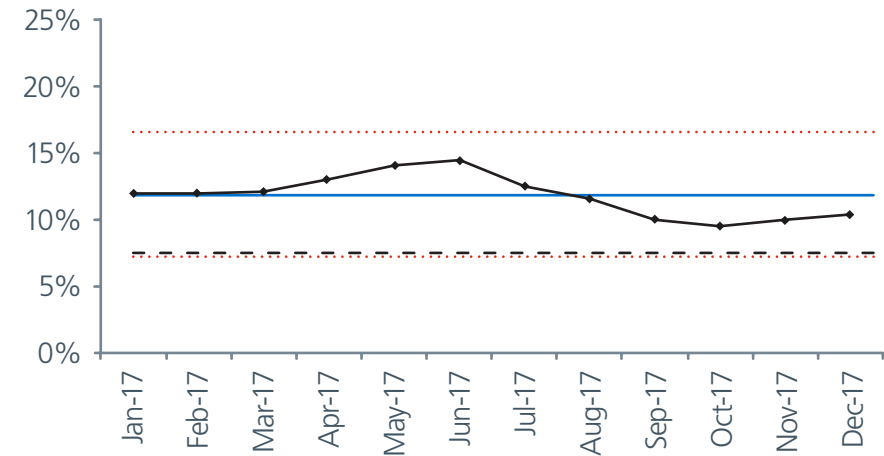
—— CL   .... UCL   LCL   - - - Target   —◆— Actual

On target	In control	Action required	On target	In control	Action required
Yes	Yes	No	No	Yes	Yes