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Quality improvement in anaesthesia

Edited by Dr Carol Peden



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1. The science and history of improvement

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As anaesthetists, we find ourselves firmly at the centre of the quality and safety agenda. Patient safety is core to all aspects of the College's training, education and standards for anaesthesia. Our strong history of nurturing a safety culture, learning from mistakes, preventing harm and working as part of a multidisciplinary team all contribute to the disciplines of safety and anaesthesia.

The cause of The Patient Safety First Campaign¹ was to make patient safety a top priority and to create a mindset of 'no avoidable death and no avoidable harm'. The campaign ethos was, 'by the service, for the service', with frontline NHS staff being both the face of the campaign and leading locally driven change. There were five clinical interventions, namely; leadership for safety, reducing harm in peri-operative care, reducing harm from high risk medications, reducing harm from deterioration and reducing harm in critical care. The first intervention recognises the importance of strong leadership to foster a safety culture and as anaesthetists, we frequently lead service provision and the multidisciplinary team. The next two interventions have directly impacted on us and our patients, with the implementation of the Surgical Safety Checklist, 'wrong site' block prevention and the introduction of non-Luer type connections for the administration of intrathecal drugs. The last two interventions directly involve Intensive Care, with processes aimed at reducing ventilator associated pneumonia and central venous catheter-related blood-stream infections, and process reliability utilised to ensure early warning scores are recorded. Consequently, bundles, processes and checklists are all now terms, which are familiar to practising anaesthetists. Many of these concepts arise from Improvement Science.

For those of us trained in medical research based on the testing of hypotheses with randomised controlled trials (RCTs), we may struggle to understand where this translational science comes and question its scientific basis. However, many of the improvement and measurement techniques now being introduced into healthcare have been widely used in industry, agriculture and aviation for decades. This article introduces some of the concepts of improvement science and provides the interested reader with further references.

The 'father' of improvement science is William Edwards Deming (1900–1993) an American mathematician, statistician and business consultant.² He is credited with improving industrial production in the US during the Second World War, although perhaps better known internationally for his work in Japan from the 1950s onwards. He taught Japanese top management how to improve service, quality, product testing, and sales with a variety of methods including the application of statistical control methods. He was mentored by Walter Shewhart (a statistician at Bell laboratories) who had developed the concept of statistical control of processes using control charts and the ideas of special and common cause variation. Deming is regarded as having had more impact upon Japanese industry than any other individual of non-Japanese heritage. Later in his career in the mid 1980s he is credited for transforming Ford Motor Company, from failure to the most profitable American car manufacturer at that time. The then Ford Chairman said: 'We are moving toward building a quality culture at Ford and the many changes that have been taking place here have their roots directly in Dr Deming's teachings.'

Deming's work shows that the processes used in improvement science are not only firmly based on statistical science, but have also been tested and shown to work successfully to improve many different complex processes.

In addition to statistical process control methods, Deming used a technique which he called 'profound knowledge' to examine a system to see where it could be improved. This process involved four parts:

- 1 Appreciation of a system
- 2 Knowledge of variation: a key to understanding the use of run charts and control charts
- 3 Theory of knowledge – i.e. the concepts explaining knowledge and the limits of what can be known
- 4 Knowledge of psychology.

All of these components interact much like a Venn diagram and a process cannot be improved upon without consideration of each part. For instance the way the individuals in an operating theatre behave, and the culture of that theatre is integral to understanding how to make that particular operating theatre safer. To improve quality

in anaesthesia and its related sub-specialties we must understand how our processes vary under normal (or common cause) circumstances, only then can we clearly identify an abnormal variation or problem.

In general, as anaesthetists, we concentrate on changing technical aspects of care, such as a new drug or a new piece of equipment, rather than the organisational aspects. These same technical innovations often prove frustrating, with the realisation that promising innovations make little or no differences to our patients' outcome, or that the evidence on which they were based is not as robust as first promised.^{3,4} Changing how the operating theatre environment actually functions when caring for patients may provide a much greater opportunity for improvement than changing technical aspects – such as which cardiac output monitor to use or the use of a new drug.⁵

We cannot improve something until we really understand it. To understand how we can make peri-operative care safer, more effective and more person centred, we must closely examine the Operating Theatre micro-systems using the 'lens of profound knowledge'. A system is defined as 'an interdependent group of items, people, or processes working together towards a common purpose ... the common purpose aligns the parts of the system, while interdependence considers the relationships and interactions among them. Interaction is amongst people, processes and equipment. Interdependence means that multiple measures are needed to understand the performance of a system'.⁶

The first step, therefore to improving a system is to examine it closely, by defining boundaries, including temporal components and to understand successes and defects within the system. Subsequent chapters will explain how to improve organisational aspects of care with corresponding examples.

The science of improvement should not threaten evidence-based medicine. To the contrary, it should complement it making it easier for the practising anaesthetist to make changes that will result in safer, more effective, efficient, equitable, timely and person-centred peri-operative care.⁷

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2.

Making improvement happen

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So you've done your audit, and identified problems; how do you now make improvement happen? The traditional method has been through education and telling people to do better. While providing information and training is always necessary and beneficial, on its own it is not enough to achieve change in the complex systems in which we work in healthcare.

'Every system is perfectly designed to get the results it gets' (Paul Batalden IHI), the only way to get real change is to change the system; to do this you need 'will, ideas and execution'.¹

- D You must have the will to make the system better – this may be because you have identified poor performance or outcome through audit or patient experience
- D You must have ideas about how you could change things for the better
- D You must have skills to make it happen – execution

The model for improvement

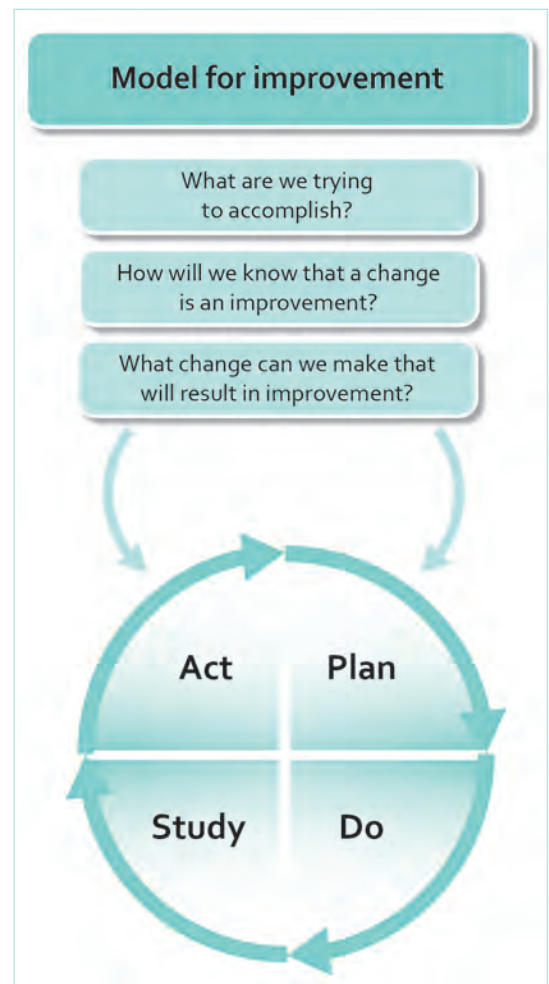
The model for improvement is the foundation tool used in improvement science developed by the Associates in Process Improvement² and derived from the work of Shewhart and Deming (see Figure 1).³ Other improvement models exist such as Lean, Six Sigma, DMAIC (define, measure, analyse, improve, control); it is more important to understand that the use of a structured approach will help to drive improvement, than which actual model you use. In this book we have chosen to discuss the simple plan-do-study-act (PDSA) cycle which uses small, rapid cycle changes designed to test, measure impact and test again.² This method uses small frequent samples to drive change in a much faster and more proactive manner than the traditional audit cycle. Anaesthetists and intensivists whose units have participated in one of the UK safety programmes such as the Safer Patients Initiative network⁴ and the Scottish Patient Safety Programme⁵ have used this technique. The three questions central to applying this improvement method² are:

- D What are we trying to accomplish?
- D How will we know that a change is an improvement?
- D What changes can we make that will result in an improvement?

The first question, 'what are we trying to accomplish', gives us our aim, e.g. we wish to improve outcome for patients undergoing emergency laparotomy. Our aim statement should be as defined as ambitious but achievable and it is worth spending time on this. In the example 'improve care for patients undergoing emergency laparotomy', consider what will be measured as an improvement and at what time point? Do we want to improve care for all types of laparotomy or only non-trauma laparotomy? Consider a different statement, e.g. 'improve mortality at 30 days for patients undergoing non-trauma emergency

Figure 1

Model for improvement, reproduced from 'The Improvement Guide'.² This material is reproduced with permission of (Wiley-Liss, Inc, Wiley Publishing Inc, a subsidiary of) John Wiley & Sons, Inc.



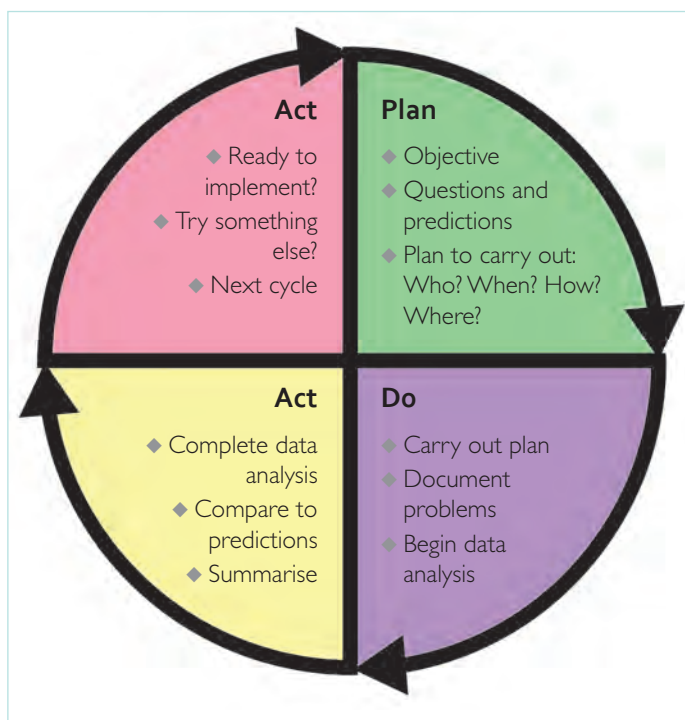
laparotomy'; this is clearer but still vague. How much improvement do we want: a 1% reduction in mortality or a 50% reduction? When do we want to see this improvement: next week or in 10 years? A clear aim statement will provide an idea of how much and by when. We should set bold aims, not totally unrealistic aims, but ones which will stretch us, in this case we are trying to save lives and so a 1% improvement is not good enough. A good aim statement for this project then becomes:

D 'We aim to reduce 30 day mortality for patients undergoing non-trauma emergency laparotomy by 20% by September 1st 2013.'

The second question is 'how will we know that a change is an improvement?' For this we will need **measures**. In the example above we have a clear **outcome measure**: a reduction in 30 day mortality. To achieve that, as part of our improvement project we will need some **process measures**. Process measures will measure what we believe we can do to improve outcome, e.g. reduce the time from admission to theatre (process measure: time from admission to theatre) and increase use of cardiac output monitoring during emergency laparotomy (process measure: percentage of patients in whom a cardiac output monitor was used during laparotomy). Whenever we are changing a system we must consider how our changes impact on other parts of the system. We therefore need **balancing measures**. For example, if we prioritise emergency laparotomy patients for the emergency theatre do we adversely impact another group of patients?

Once we have our measures we can start developing our ideas for change.⁶ As you have done an audit or want to try an improvement project you already have a good idea of what outcome you want to change; but how do you do that and where can you make improvements? First of all think critically about the system, perhaps you can process map the patient experience or make a flowchart and consider where you as an anaesthetist can most effect a change. Do you know of other units that have better outcomes – what is it that they do differently? What guidelines or research evidence is there that could be done better in your hospital? Have you considered what it feels like to be a patient in this process – what would make their experience better? With ideas generated in this way you can start to develop a change concept. If your audit showed that only 30% of patients had arterial lines for their emergency surgery and this appeared to be highly variable, you may develop a change concept aimed at reducing the variation in care for patients undergoing emergency laparotomy. A reduction in variation of care is one of the key reasons that enhanced recovery has been so successful.

Figure 2
Developing and testing a change.



Once you have a theory and/or ideas you can now start to test them. Remember 'all improvement will require change, but not all change will result in improvement'.² Let us say as that part of your change package you want every emergency laparotomy patient to have a blood gas performed in the anaesthetic room to measure lactate and base deficit. To achieve this you plan to inform that theatre team and put up a poster in the anaesthetic room. Obviously if you are a trainee you will need to have discussed this and to have senior support for this type of project.

Start on the plan-do-study-act (PDSA) cycle. **Plan** to put a poster in the emergency theatre and inform the team. **Do** this and study what happens. Start to test on a small scale, e.g. only in one operating theatre on one day. Start your testing with a team who are enthusiastic about your idea. If all patients get a blood gas at the right time, start testing on a few days. You may then find that the process becomes less reliable, therefore

study why it is now unreliable. You may find that it does not get done at night because there are no porters to take the blood gas for analysis. **Study:** how do you get round that? What have you learned about your change idea? **Act:** develop a new idea to deal with this challenge and test again. The cycle goes on, testing theories about what will work and learning from what does not work (Figure 2). If it works during a weekday night, does it work on a weekend night? Do not assume your process is reliable until you know it works with different teams and at different times of the day and night. It must work without you being there to drive it.

Some examples of PDSA cycles are given in the next two sections. They illustrate how difficult it can be to achieve reliable implementation of apparently simple processes such as keeping the patient warm. The references provide sources of further reading and examples.

Finally, while this may appear to be an apparently new concept, it differs very little from the concept of differential diagnosis and treatment plan practised in the art of medicine and anaesthesia. For example, your patient is tachycardic with a normal intra-operative blood pressure in theatre. Your theory is that the patient has insufficient anaesthesia and analgesia. Your **plan** is to increase the delivered amount of inhalational anaesthetic and to give a bolus of opiates. **Do:** you increase the depth on inhalational anaesthetic to 1 MAC and titrate incremental boluses of opioid. **Study:** The patient remains tachycardic but is now becoming hypotensive, despite your treatment. **Act:** You now believe the patient to be inadequately resuscitated and your new theory is to give a fluid challenge. A new PDSA cycle now starts with this new theory from your previous testing.

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3.

From audit to action

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Completing an audit is only the beginning

The Healthcare Quality Improvement Partnership defines clinical audit as 'a quality improvement cycle' that involves 'taking action to bring practice in line with (agreed and proven) standards' in order to improve quality of care and health outcomes.¹ While it can be relatively simple to perform an initial audit, taking the next step and improving care quality is much harder.

Identifying the area for improvement

The first step is in identifying what you want to change. Trainees often have insight into variations in practice across a region and may have seen examples of practices that work well and could be adopted more widely. Other sources of ideas for quality improvement projects might come from NICE guidance, Royal College or professional society guidelines, or the findings of confidential enquiries such as NCEPOD. As an example, the use of capnography for out-of-theatre intubation (OOTI) has been recommended in the report of the 4th National Audit Project of the Royal College of Anaesthetists,² and is endorsed by statements from the AAGBI and the Intensive Care Society.³

Evidence and expert opinion

Any quality improvement project requires evidence that compliance will improve outcomes. This might come from randomised controlled trials, smaller non-randomised studies or even expert opinion and guidance from bodies such as NICE, as described above. In our example, we found evidence that implementation of an intubation bundle including capnography use reduced the rate of adverse events associated with intubation on the Intensive Care Unit.⁴

Identifying current practice

The next step is an audit of current practice. Without this step it is hard to motivate people to change their practice. Co-ordinating an audit across a region can be hard but again trainees can hold the key to this. Where formal audit networks exist they are ideally suited for this, but in their absence informal networks of trainees or consultants work just as well. However, it is vital to ensure that within each trust the appropriate audit registration procedures are followed and that each department is aware of the process from the outset.

In the Severn region, a group of trainees from a variety of base specialties with an interest in ICU set up a network called RTIC Severn (Regional Trainees in Intensive Care). This group included representatives working at all of the trusts in the region and made it possible to co-ordinate our activity across a much wider area. One representative trainee from each trust was given the responsibility of leading the audit process within that trust and of getting the approval of the local anaesthetic and critical care department.

We performed a region-wide prospective audit of OOTI practice, which identified wide variation in the use of capnography between trusts, and also identified other areas where improvements could be made. The dispersed nature of the RTIC Severn group made it easy to perform the same audit at multiple sites simultaneously. The nominated trainee at each trust was responsible for optimising data capture and quality, although the methods they used were left up to them.⁵

An intervention to improve practice

In general, simply exhorting people to 'do better' is not effective at increasing quality. It is more effective to introduce processes with the quality interventions you seek to introduce built-in. The development of standardised processes can empower junior doctors, nurses and other staff to demand certain standards of care

that they might otherwise not be aware of, or might feel they could not ask for. One example of this is the use of the WHO surgical safety checklist to empower theatre staff to require surgeons to engage in a pre-theatre safety brief. In our example, we decided that an intubation checklist would allow us to standardise intubation practice regionally and to prompt trainees to request safety equipment, such as capnography, prior to commencing intubation.

Development using PDSA cycles

Once a new process has been designed it is important that it works in the environment that it will be used in. If staff can not understand the rationale for new processes they may feel that they are being imposed on them for no reason. Using plan-do-study-act (PDSA) cycles as described by the Institute for Health Improvement (see relevant sections of this book) allows users to design the process so that it makes their life easier, while retaining the quality improvement effect. They also then 'own' the process and will be much more likely to use it than a process that has been imposed on them from above.

In our example, the intubation checklist went through several iterations in a single centre before reaching a consensus version that was ready for wider trials.

Motivating people to change

Once you have a working process you can start to spread it out within your region. Again, your network is invaluable here and there are many ways to encourage people to take up your intervention. Presentation of the original audit, revealing differences in practice across a region together with the evidence supporting your intervention, is a powerful tool. Where capital investment is required then it is important to look at cost-effectiveness data, in order to present a robust business case for investment. Some quality improvement projects may attract CQUIN (Commissioning for Quality and Innovation) payments.

Our audit data was presented both to individual departments and regionally, and has now been published.⁵ All the hospitals in our region were involved in developing the checklist, which is now in use both in anaesthesia/ICU and emergency departments throughout the Severn region. The checklist featured as an appendix to the NAP-4 report and we are now expanding our network further afield, both in other regions of the UK and internationally.

Documenting your success

The process of quality improvement is ongoing and it is important audit practice to ensure compliance. Where specific quality indicators have been identified, it is useful to document an improvement in these to encourage people to continue to engage with the process. Finally, you should continue to survey your practice over time to ensure that standards do not slip and to demonstrate the effectiveness of your intervention.

This article has been written on behalf of the RTIC Severn group. This is a group of junior doctors with an interest in intensive care medicine and patient safety. Involved in this project were: Andrea Binks, Tim Bowles, Hamish Breach, Michelle Chopra, Sara Cook, Nick Dennison, James Dunn, Dan Freshwater-Turner, Miguel Garcia-Rodriguez, Gareth Gibbon, Subbu Halder, Clare Hommers, Katie Howells, Rob Jackson, Andrew Jacques, Dom Janssen, Abby Lind, Nina Reeve, Kieron Rooney, Sarah Sanders and Anoushka Winton.

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4. Improvement basics: driver diagrams

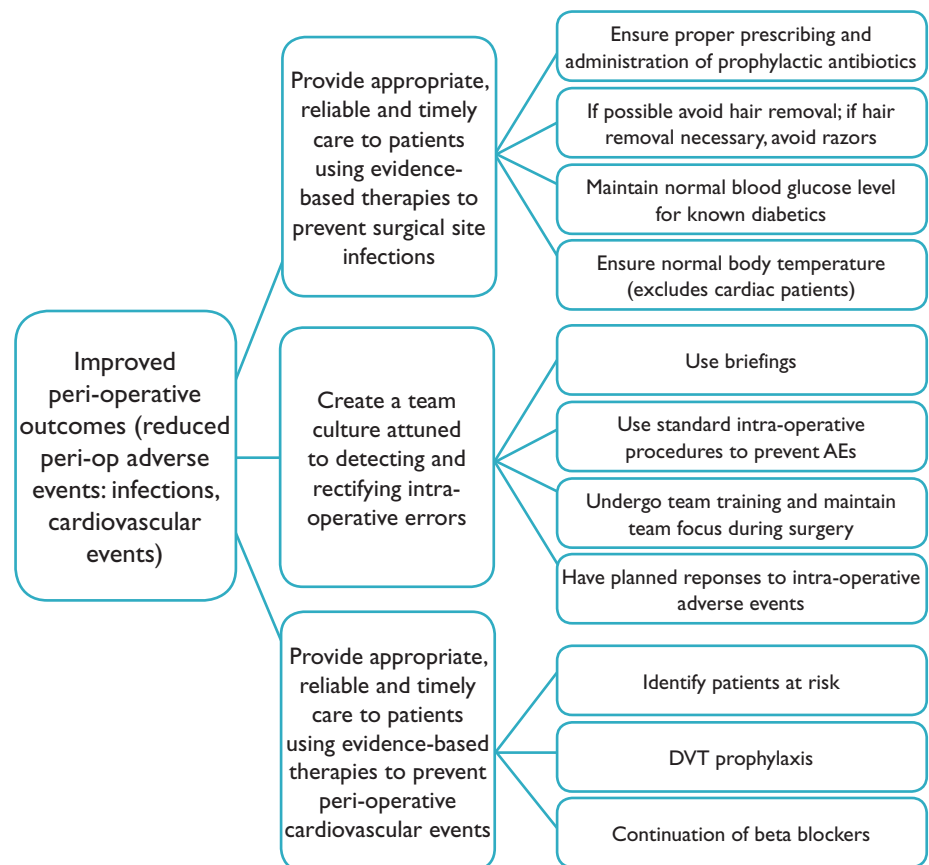
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Quality improvement uses a structured approach to change, and aims to improve reliability of healthcare delivery. If we want to improve care for a particular patient group or condition then we need to set a clear aim as discussed in section: 'Making improvement happen'. We then need to formulate change concepts and to develop a change package to understand how best to deliver the improvement. A driver diagram can be used to illustrate the aim and to link the primary drivers, the key areas that can be worked on to 'drive' change, to achieve the desired outcomes. The primary drivers are then linked to secondary drivers, the specific change concepts that can be used to create projects that can be worked on to realise the desired outcome. Figure 1 shows an example as used in one of the national safety programmes.¹

Figure 1.

Driver diagram for peri-operative care as used in the Scottish Patient Safety programme.



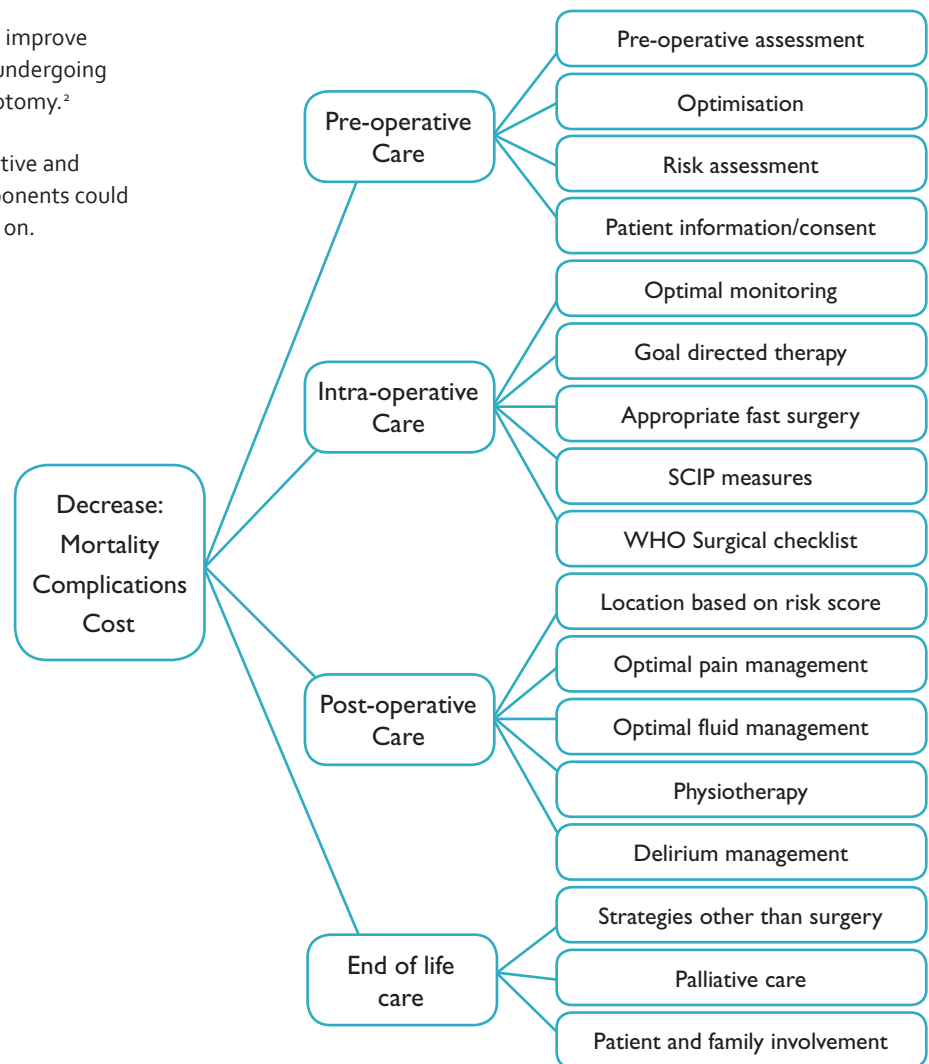
You can develop a driver diagram to assist with your own improvement project. Specify your goals in the lefthand box of the driver. For example, I created a driver diagram to improve care for patients undergoing emergency laparotomy.² The goals are to decrease mortality, complications and cost. To achieve those goals we will need to work on the primary driver areas: pre-operative care, intra-operative care, post-operative care and end of life care. If you were a surgeon working on this project you may want to add another driver, such as, to improve screening for bowel cancer. Remember, that it is best to work on areas where you can have most impact. Therefore as an anaesthetist, I may want to develop secondary driver components to develop projects to work on the intra-operative care driver. For my diagram I chose to add the intra-operative projects shown, but you could add others, such as presence of a senior team for this surgery.

Try developing a driver diagram for a project area you are interested in. This way of thinking can be very helpful to demonstrate the number of areas you can work on to get improvement for your goal. When you have done your driver diagram pick a secondary component to work on, remember to pick an area where you can influence change, and start working with enthusiasts who will support your change ideas.

Figure 2

Driver diagram to improve care for patients undergoing emergency laparotomy.²

This is not exhaustive and many other components could be added to work on.



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5. Improvement basics: bundles to improve reliable delivery of care

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The ventilator bundle and the central line bundle are all familiar to anaesthetists and intensivists; but how do you create a bundle and what are the principles behind a bundle?

A 'bundle' is a group of interventions for a given disease that, when implemented together, may result in better outcomes than if implemented individually. A bundle does not have to include every process related to that area of care – it is designed to improve delivery of related aspects of care to the patient. The use of a small number of evidence-based interventions and the collection of data based on their delivery, leads to the recognition that it is really hard to deliver 3–5 components of care 95% of the time. Most teams when they start measuring will find their performance for bundle delivery is between 20 and 60%. If you deliver each component of a five element bundle at 90%, then $5 \times 90\%$ means you are delivering an overall performance for this bundle of 59%. Use of a bundle promotes awareness that the team must work together to get all the components delivered reliably, and to use improvement methods to redesign care processes.¹ Examples are: the use of multidisciplinary rounds and daily goals to reinforce bundle compliance, e.g. planning the sedation hold for a ventilated patient.

These are the features of bundle design:¹

- D The bundle ideally has 3–5 actions agreed upon by clinicians (any more interventions will reduce reliability, as explained above, e.g. seven elements \times 90% delivery = 48%).
- D The steps are all necessary and each step must be performed to achieve success.
- D The multidisciplinary team develops the bundle.
- D Elements should be descriptive rather than prescriptive, e.g. DVT prophylaxis on the ventilator bundle does not define what the prophylaxis should be.
- D Each step is individually based on level 1 evidence if at all possible.
- D Each step should be clear-cut and all-or-nothing. The answer to completion of the step can only be 'yes' or 'no'. For example in the ventilator bundle: was the sedation stopped this morning? The answer has to be yes or no.
- D The bundle must take place in the same time and space continuum; for example the central line bundle takes place during a single episode of line insertion, and assessment of the ventilator bundle is made during the ward round.
- D There should be no controversy about each step. The bundle is about how to deliver best care, not what the care should be.

As delivery of the bundle components reaches more than 95% reliability, teams can consider what other components would improve care. As delivery of the care bundle improves teams should see a parallel improvement in related outcomes, e.g. increased reliable implementation of the central line insertion bundle, should correspond with a decrease in central line bloodstream infections.

Studies indicate that, by using care bundles as part of a comprehensive improvement strategy, clinical outcomes improve.^{1,2,3} Part of the problem with the adoption of care bundles can be the lack of agreement on which measures to monitor. This does not detract from the value of a bundle if it is accepted that bundles are not the 'answer' to the problem, they are just one tool that can be used in the design of services within an environment of continual improvement. The goal is to ensure that evidence-based care is reliably delivered every time it is needed.⁴

The success of the central line bundle in the US, after Pronovost and colleagues demonstrated that an intervention including care bundles used in 103 ICUs decreased infection rates by up to 66%, led to the state-wide implementation of the bundle in Michigan.^{2,3} Teamwork and communication were identified as key to the improvements seen.³

Designing your own bundle:¹

- D Agree on a set of elements to initially test against a small number of records to understand the baseline (if all elements are very low individually reconsideration may be needed)
- D Test with a small sample to identify the barriers to each of the elements in terms of measurement and practicality of implementation
- D When practical elements are identified move to testing in a single unit or clinical area
- D If clinicians do not choose the individual element about 80% of the time, as you 'scale up' reconsider or reformat the element
- D Design the bundle with the aim of achieving 95% reliability.

You can also use bundles to create customised protocols and pathways specific to your hospital. For example, the Surviving Sepsis campaign suggests that the 'Severe Sepsis Bundles' are designed to allow teams to follow the timing, sequence, and goals of the individual elements of care, to achieve the goal of a 25 percent reduction in mortality from severe sepsis.⁵ Individual hospitals should use the bundles to develop their own pathways incorporating the bundle elements with the understanding that all of the elements in the bundles must be used and the addition of other strategies not found in the bundles is not recommended.

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6. How do you know a change is an improvement?

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Data collection is part of all audits. The collected data are often presented in summary format either as a single numerical figure or as two numbers before and after an event. Whenever two numbers are compared they are likely to be different. Anything that is measured will be found to vary over time. Summarising data in aggregate blocks removes the vital clues that exist in plotting data on a graph in time series. Plotting each data point over time allows construction of a run chart; a simple but powerful tool for examining whether a change has occurred.¹

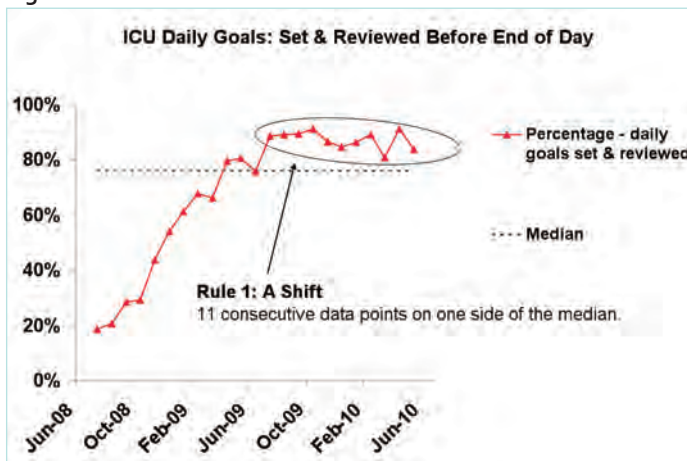
How to construct a run chart

Plot time on the x-axis and the measurement on the y-axis. Enter your data. Once the data are plotted calculate and create a central line using the median (the middle value). Using the median as the centre line has two advantages: it is the point at which half the data points lie above and below the centre line, and it is also resistant to the effects of extreme outliers. All spreadsheet programmes will have a command for this.

How do you know a change is an improvement using a run chart?

Often when we look at data we can over react to the data and apply subjective rules to affirm whether a 'shift' has occurred or whether a 'trend' is present. There are specific rules that can be applied to a run chart to determine whether a non-random change has occurred. This first three of these are based on the laws of probability.

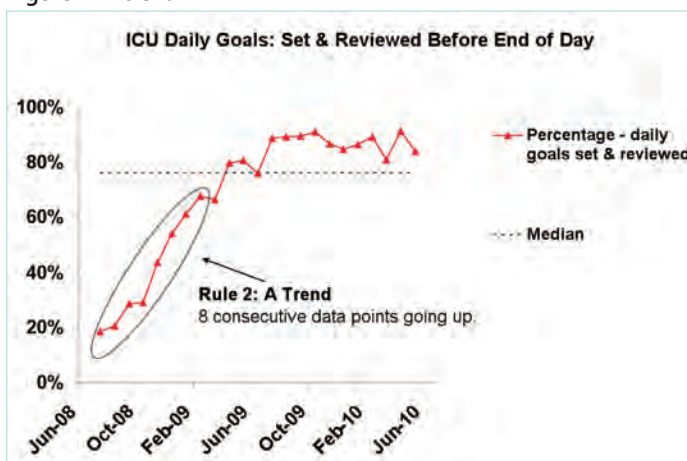
Figure 1 A shift



Rule 1: A Shift

A shift has occurred when six or more data points lie on the same side of the median (Figure 1). This can be either above or below the median. When counting data points some may lie on the median, these do not contribute to a run, ignore these data points and continue counting.

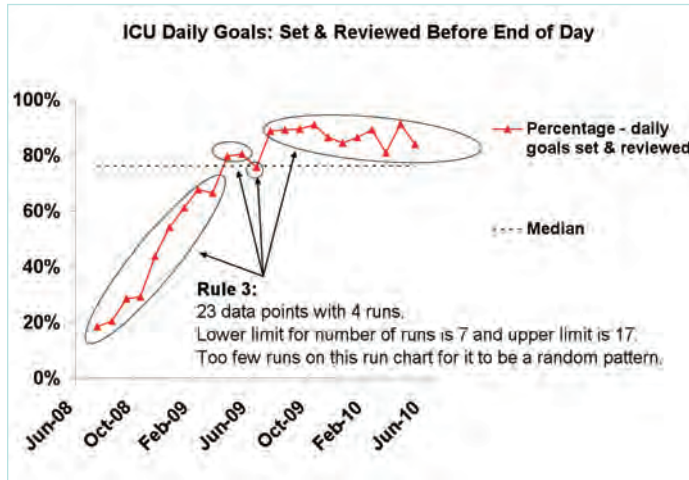
Figure 2 A trend



Rule 2: A Trend

A trend has occurred when there are five consecutive data points either increasing or decreasing in sequence (Figure 2). Trends can cross the median. If any consecutive data points are equal only count the first data point, ignore any repeating values, and continue counting.

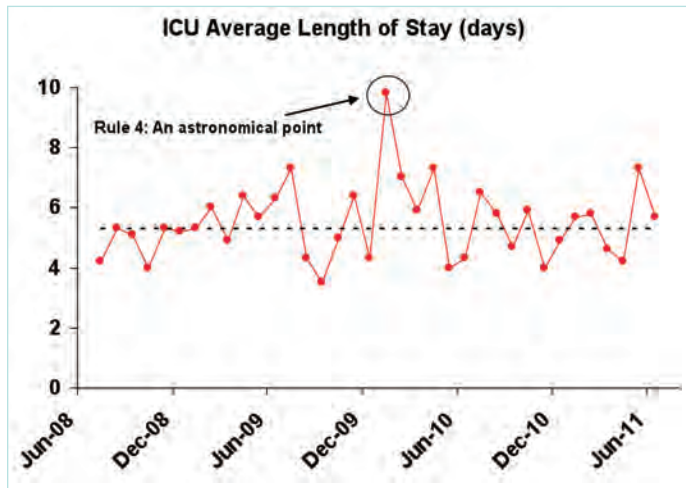
Figure 3 Number of runs



Rule 3: Number of runs

A run is a series of data points on one side of the median. A data point or points that lie on the median do not interrupt a run. The number of runs can be simply calculated by counting the number of times the line connecting the data points crosses the median, then add one. If the data in the time series are random, the median should be crossed a certain number of times given the number of observations made (Figure 3). A table exists that compares the number of data points and the expected range of how often the median should be crossed,² this allows us to determine if there are too few or too many runs.

Figure 4 Astronomical point



Rule 4: An Astronomical Point

This rule aids detection of unusually small or large numbers. All run charts will have a lowest and highest data point; an astronomical point is blatantly different from the rest of the data points and is something that anyone looking at the chart would agree with (Figure 4).

Using run charts

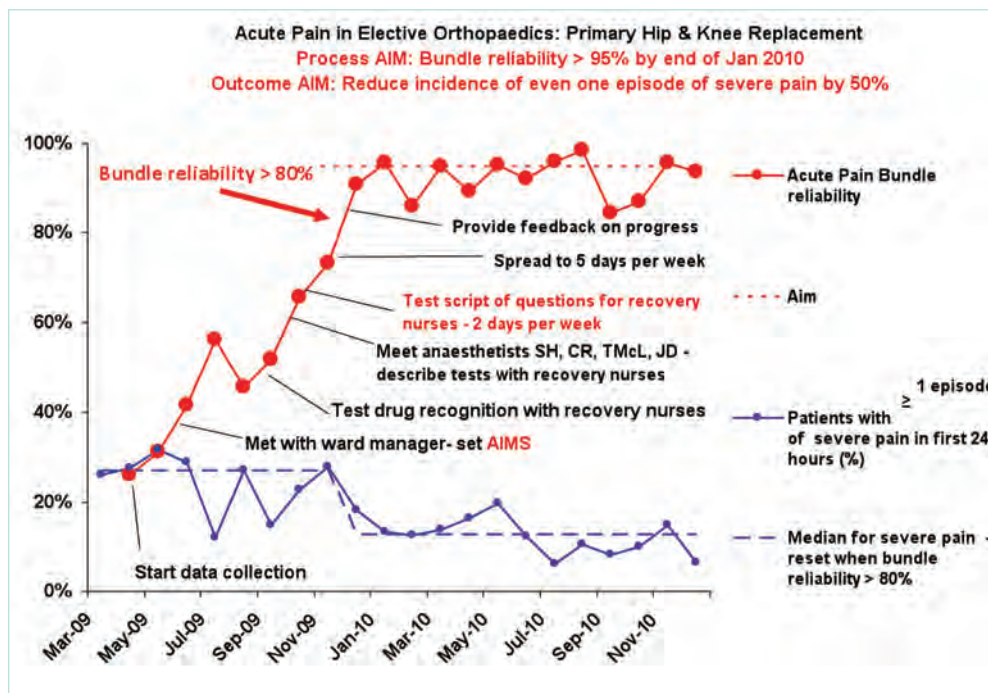
Run charts can be constructed once there are ten data points. When initial baseline data shows random variation, the median can be calculated and then projected into the future on the chart. Data acquired later in the improvement project will not affect this median that can be used for comparison. This allows for non-random changes in the data to be detected clearly.

There are three important uses for a run chart. Firstly, a run chart displays measures over time and makes progress visible to those on the team. Secondly, a central tenet of improvement is that all improvement requires change, but not all changes lead to improvement. A run chart and the rules can be used to determine if a change has resulted in an improvement. Annotating the run chart with the times at which changes were made makes this an important use for run charts. Thirdly, the run chart has time-series data, this is particularly useful to help determine if the gains are held after a change has been implemented.

Run charts are good for detecting changes, either an increase or decrease in a measure. Run charts cannot be used to determine if a measure, process or outcome, is stable. This requires the construction of a Shewhart, or control-chart, and requires additional software or a plug-in for the spreadsheet program. For almost all audit projects a run chart will be sufficient. When more than 50% of measures are either 0% or 100%, a reliable median cannot be drawn. In this case a run chart using time between events may be more useful.

Run charts are simple to construct. The simplicity, together with the probability-based run chart rules provide an easy yet powerful method for assessing the impact of changes made. This provides an objective method to determine whether the changes made to the process have led to an improvement that has been sustained over time. When improving a process to improve an outcome, a powerful way to present the data is with both these measures plotted on the same run chart using a secondary y-axis. This provides a powerful display of the linkage between improving a process and improving an outcome (Figure 5).

Figure 5 Linkage between process improvement and outcome improvement



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7. A quality improvement project: temperature on arrival in the Post Anaesthetic Care Unit (PACU)

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Aim: to ensure that 95% of all patients arriving in PACU have a temperature of 36 degrees or more within six months of the project start.

Baseline data: start measurement to collect baseline data. Large numbers are not necessary, 20 random samples a month tell us how we are doing.

Method: monthly random review of 20 patients (% per week) by PACU nurses.

Initial results: the nurses did not find this onerous; our initial compliance was 60%.

Continued measurement vital to demonstrate improvements resulting from interventions. Each intervention must be tested initially in a small group of patients with a PDSA cycle to check it leads to an improvement, or to learn why it does not.

Initial actions: Multidisciplinary group established to lead improvements while measurement continued monthly to see impact of practice change. Education on NICE guidelines performed. This led to increased awareness and more measurement to find out which groups of patients were prone to cold. Measurement, started in each of our 3 theatre complexes, of 20 patients per month (60 patients per month).

PDSA test established that temperature was not reliably recorded peri-operatively and various PDSA tests were done to find reliable ways of ensuring that the patients' temperature was always taken at the beginning of the operation. This resulted in a temperature check being added to the 'sign in' of the WHO checklist, leading to very reliable temperature measurement.

The monthly measurement also included details on those who were cold, and revealed that patients having a laparoscopy were often cold, and many of our patients were receiving cold fluids, outside of NICE guidance.

Reliable warming of IV fluids of more than 500ml was established (see PDSA ramp, Figure 1). These measures increased the number of our patients reaching PACU with a temperature of 36 degrees or more from 60-80% over 6 months.

Figure 1 Process change PDSA. Temperature > 36°C in PACU

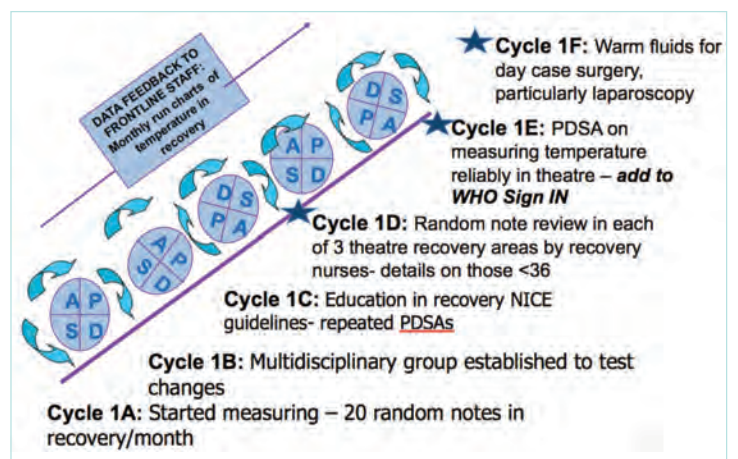


Figure 2 'Stop the Drop' poster

Prevention of Intraoperative Hypothermia
Being cold increases the risk of complications following surgery, e.g. wound infections, cardiac arrhythmias.
Keeping patients warm before coming to the theatre is essential.

'STOP THE DROP'

- Temperature **1 hour** before leaving for theatre
- **If temperature less 36.5**
– extra jumper/blankets/ socks/slippers
- Patients **walk** to theatre if able
- If not walking – **2 blankets**

(NICE guideline 65)

Royal United Hospital Bath **NHS**

Problems: Interestingly, when IV fluid warmers were temporarily unavailable, the monthly data immediately demonstrated the decrease in temperature associated with administration of cold fluids; subsequent poor compliance with fluid warming, was easily reversed by showing the data. Random audits showed reliability of > 80% for the following year. New electronic medical records have allowed us to collect data on all patients. This information has been fed back to all theatres and to each anaesthetist and has allowed more PDSA testing of further improvement cycles. A simple policy of ‘Stop the drop’ in theatre and on the ward was commenced in one operating theatre initially, and on one operating list (see Figure 2).

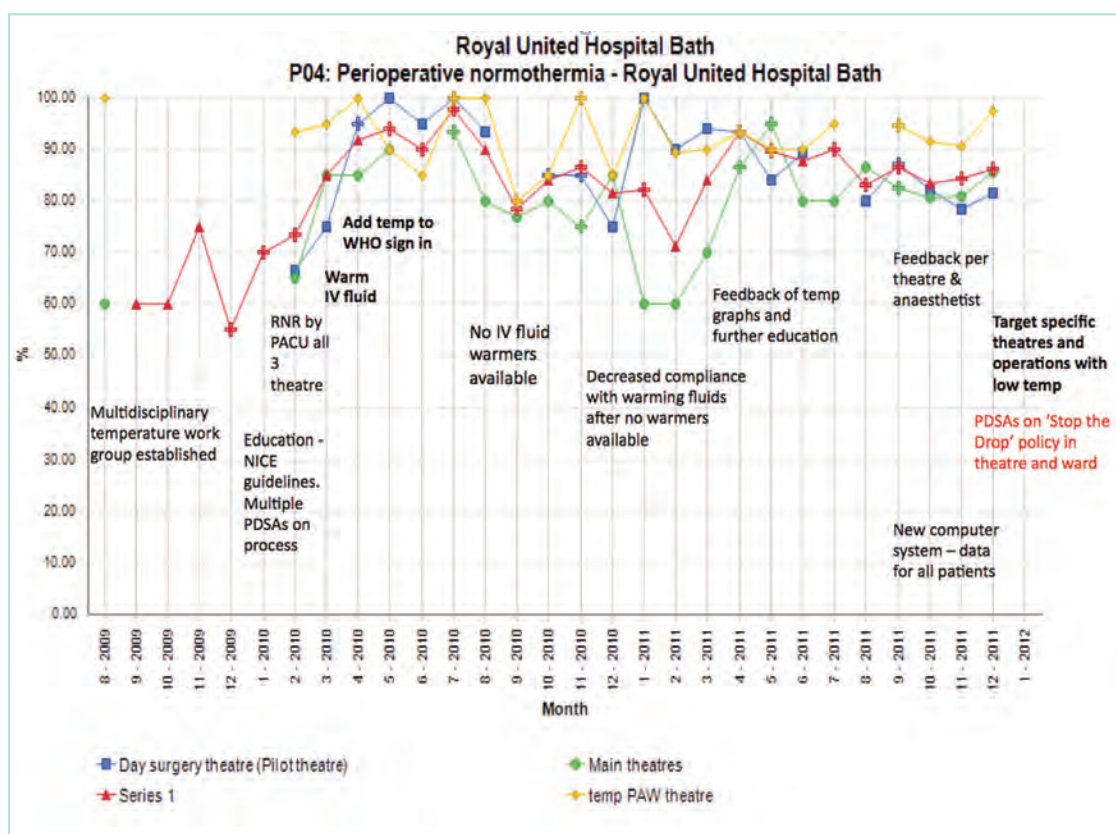
Ongoing improvement: Continued feedback of monthly data for all patients is ongoing and used to engage staff and demonstrate improvement.

Other more specific measures have been implemented to address other findings from the data, e.g. warming irrigation fluid for shoulder surgery.

The percentage of patients that are warm on arrival in PACU is now displayed in the coffee room every month so that all staff can see the effect of any improvements (see Figure 3).

We continue to work towards a goal of 95% of patients being warm on arrival in PACU.

Figure 3
Run charts from different operating theatres showing slow improvement and documented interventions.



Reference

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8. A quality improvement project: the productive trauma theatre

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Background

The spiralling costs of the NHS, added to the current economic crises, have made the development of management efficiency strategies paramount. This cost quality relationship is particularly challenging within the theatre environment where capacity and resource constraints have resulted in a supply demand mismatch.¹ With operating room running costs estimated at some £1,200 per hour and in an attempt to tackle this complex problem attention has turned to reducing the wide variety of non-operative activities and delays.^{2,3}

The Royal Alexandra Hospital in Paisley serves a population of over 200,000 and runs the busiest trauma service in Scotland. The diverse throughput of the trauma theatre, added to the ever-increasing demands placed on this emergency service, make managing this important clinical resource exceptionally difficult. Recent imbalances in the trauma service have increasingly resulted in elective theatre cancellations or 24 hr postponements, despite the theatre running 7 days a week. With mounting clinical pressures the Orthopaedic Department raised the possibility of introducing evening trauma sessions as a potential solution, leading to a hierarchical desire to review this highly valued service.

Project aim

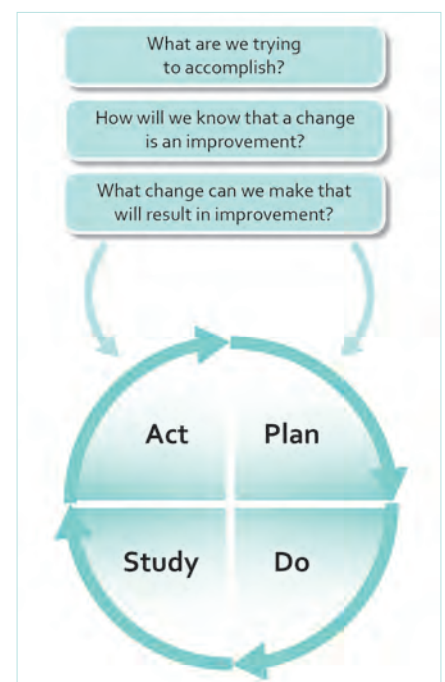
To evaluate the efficacy of the emergency trauma theatre at the Royal Alexandra Hospital and implement changes to the peri-operative patient journey that improves start, finish and turnaround times. Specifically we aimed to improve trauma theatre start time, during the week, by an average of 30 minutes from 09:30 to 09:00 within three months of project commencement.

Project methodology

In accordance with the highlighted 'model for improvement' (Figure 1) a project team was initially established that comprised of NHS operational managers, university staff, orthopaedic surgeons, anaesthetists, orthopaedic nurse specialists, frontline theatre and ward staff.⁴ The team met regularly in person or through online discussion during the study period to problem solve issues and guide implementations. Baseline data analysis (preceding 3 months) of the OPERA theatre management system was undertaken to evaluate theatre efficiency.

Following an initial brainstorming 'non-value added steps' in the current patient journey through the trauma theatre were identified by process mapping.⁵ Several patients were formally shadowed in real-time (around 200 hours) from arrival in A&E, through trauma ward admission to transfer to recovery and the anaesthetic room. All steps, interactions, waiting intervals, transfers and communications experienced during this journey were recorded whether positive or negative as if we were 'walking in their footsteps'.⁶ Time intervals were simultaneously noted allowing the trauma patient care experience to be accurately mapped. Additional information was gained through further ad hoc documentation by the patients throughout their journey, formal questionnaires (patient, family and

Figure 1 The Model for improvement, reproduced from 'The Improvement Guide'.⁴



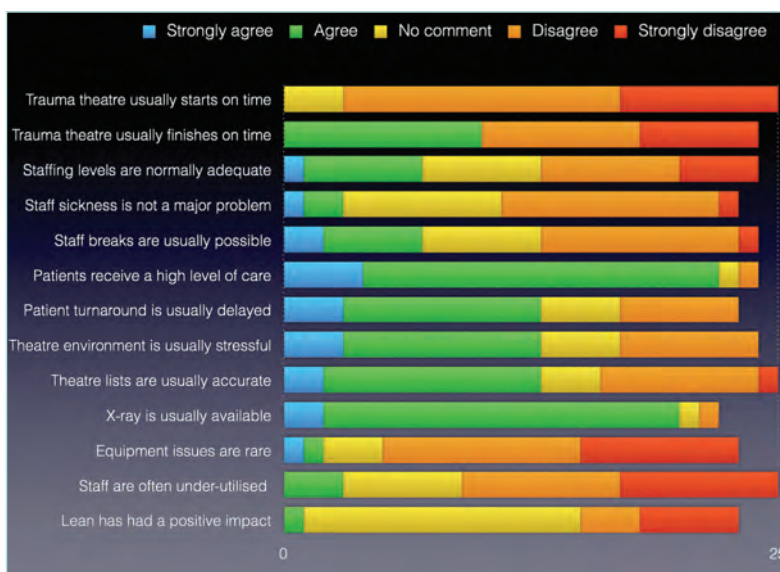
staff), multidisciplinary interviews, pareto and root cause analysis. Specific areas for improvement or inefficiencies highlighted during this process were then utilised to guide service redesign by constructing an 'ideal' trauma patient care experience.

Taking our project aim into careful consideration, implementations (change concepts) to clinical practice were then undertaken by the project team through repeat plan-do-study-act (PDSA) cycles. These change concepts included the provision of a trauma theatre list (highlighting as a minimum the first patient) before 08:00 to theatre reception, the first patient being sent for by theatre reception at 08:00, a dedicated trauma porter, formal documentation of blood results and group and save status in theatre section of the medical notes, surgical team brief sharply at 08:45, common equipment checks to be undertaken overnight and the introduction of a discharge leaflet. Data was collected prospectively on a weekly basis during the study period (3 months) both independently by the project team and from OPERA, the theatre management system.

Project results

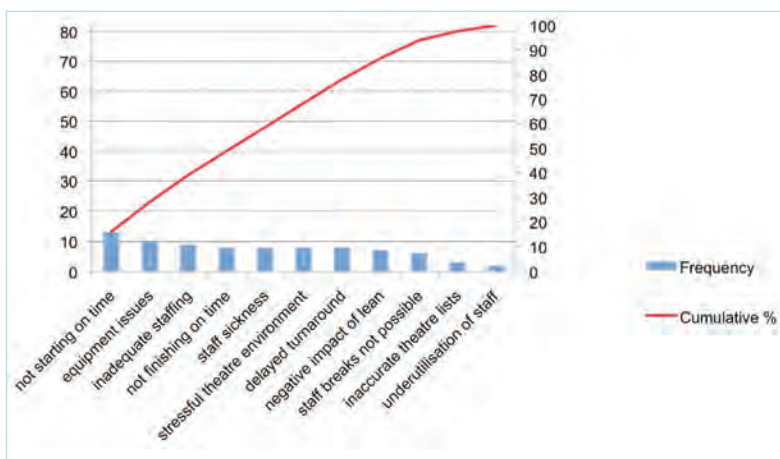
Baseline OPERA analysis of Monday to Friday trauma cases identified an average theatre start time of 09:29 (defined as time first patient enters anaesthetic room), 3.88 cases per day and procedure time of 52.9 minutes.

Figure 2 Overview of trauma theatre staff questionnaire



An initial staff questionnaire used to bring to our attention common issues from their perspective was completed by twenty-five staff (11 doctors, 5 staff nurses, 1 ODP, 4 theatre sisters, 2 auxiliaries and 2 radiologists) of varying durations of employment at the hospital and highlighted theatre start time, equipment and staffing issues as the main areas for concern (Figure 2). Patient process mapping (Table 1) and the resulting pareto chart (Figure 3) was in agreement with staff perceptions further stressing the potential impact of improvements to theatre start time.

Figure 3 Pareto chart



A driver diagram was constructed targeting this aim with developed change concepts trialled through repeat PDSA cycles (Figure 4). Prospective OPERA data analysis at 3 months demonstrated an average theatre start time of 09:11, 4.31 cases per day and procedure time of 53.3 minutes. Overall median trauma theatre start time improved by 16 minutes during the study period as depicted in the run chart and representing a non-random change in trauma service (Figure 5).

Comment

Improvements to the quality of care experienced by patients and family members alike by providing appropriate cost effective expert treatments safely, timely and in a friendly manner should be the objective of every healthcare system. The ever-diverging trend of imbalances in healthcare provision however makes meeting these goals increasingly challenging. Ironically this has resulted in a move towards 'patient-centred care' as a means of cutting costs through elimination of 'waste' and improved clinical efficiencies.

The results of this study demonstrate the potential impact, in a relatively short period of time that a quality improvement project can have in any given multi-disciplinary system. Indeed in as little as 3 months the project team successfully managed to demonstrate a change in service provision with improved average trauma theatre start time and caseload. The power of patient shadowing and subsequent journey mapping to identify potential bottlenecks or inefficiencies across all aspects of the system should be acknowledged and we continue to use this valuable tool.

Taking everything into consideration by far the most challenging aspect of this project was changing the pre-existing mind-set and culture of the healthcare professionals involved. In this regard it became readily apparent at an early stage in this process that clear, two-way communication from top to bottom at all times was key to the successful implementation of change.

While our study was prospective in nature it should be noted that we had no control group for comparison and our results therefore could have reflected other unforeseen changes in practice. In summary this pilot project has triggered a positive process of change within our institution that importantly is applicable to many other similar areas.

Table 1 Example of patient process mapping

Step number	Step	Min minutes	Max minutes
1	Trauma theatre list arrives in reception for 8am		
2	Ward nurse does preoperative checks	4	6
3	Pt changes into gown	4	4
4	Anaesthetist sees pt on ward	2	7
5 Δ	Time taken for porter and nurse to arrive on ward after pt sent for	2	19
6	Pt empties bladder/ catheter bag emptied	2	3
7	Theatre nurse presurgical checks on ward	2	5
8 Δ	Wait for drugs to be administered to pt before theatre	10	10
9 Δ	Time spent looking for forms on ward	1	9
10	Nail varnish removed on ward	3	3
11	Nurse, pt and porter go from ward to theatre reception	2	5
12	Con anaesthetist sees pt in reception	3	3
13 Δ	Nail varnish removal	3	3
14 Δ	Pt waits in reception for surgeon to arrive	29	29
15 Δ β	Delay as other patients having ECG done in reception	19	19
16 Δ	Waiting for anaesthetic nurse check	11	19
17	Anaesthetic nurse preoperative check	1	6
18 Δ	Nurse goes to get theatre gown for pt's parent	2	2
19 Δ	Con surgeon signs consent form in reception	2	3
20	Pt leaves reception and enters anaesthetic room	1	2
21 Δ	Delay as wait for consultant anaesthetist	2	14
22	Anaesthetic time	8	35
23	Time from entering OR until first surgical incision	2	42
24	Total knife to skin time	2	48
25	Transportation from OR to recovery	1	2
26	Handover from anaesthetist to recovery nurse	1	2
27 β	Total time in recovery	37	119
28	Transportation time from recovery back to ward	2	5

Δ = patient waiting β = bottleneck

Figure 4 Example driver diagram

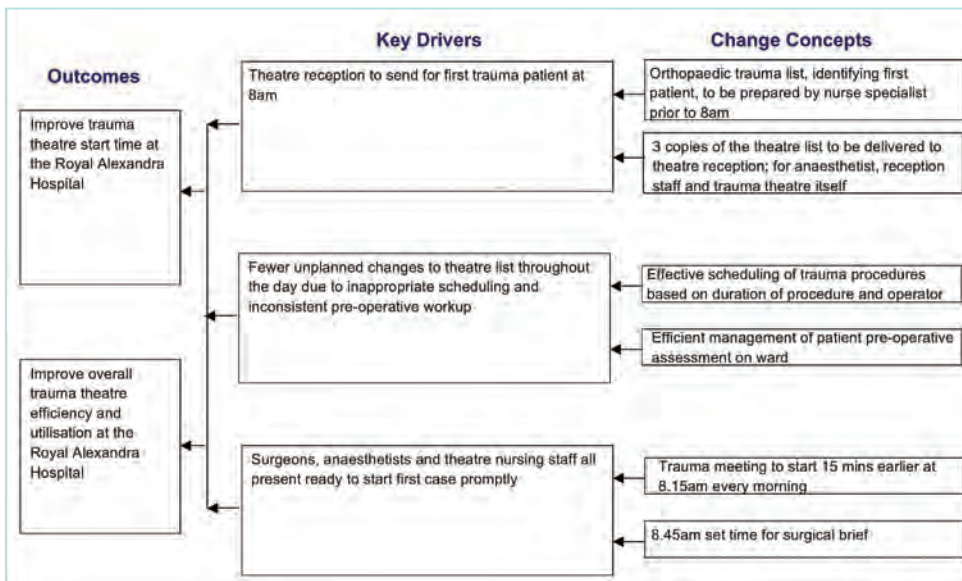
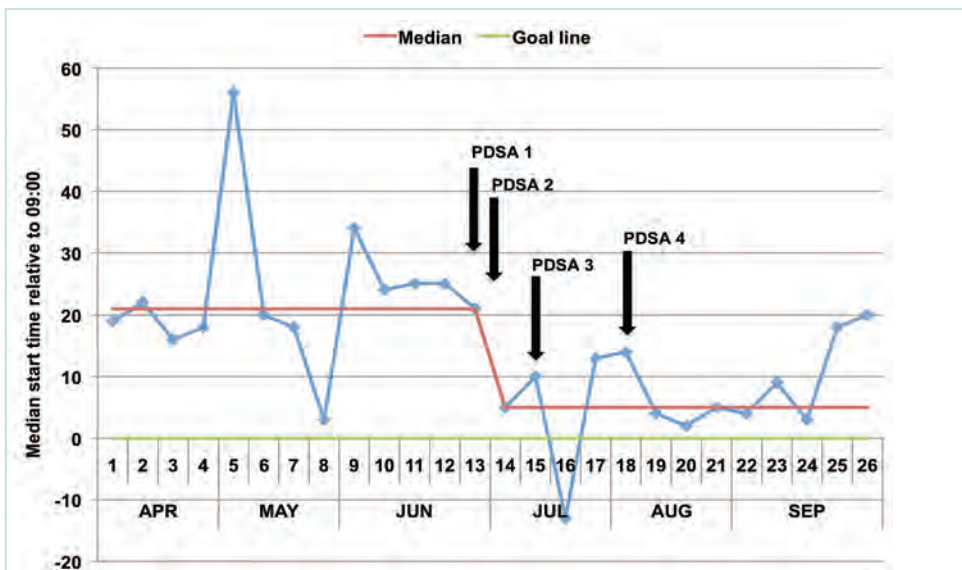


Figure 5 Run chart of theatre start time (relative to 09:00) from baseline (Apr – Jun 2011) through to study period (Jul – Sep 2011)



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9. Studying patient harm and death to improve care: structured mortality review, global trigger tool and HSMR

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Mortality review is a standard part of any audit and quality improvement programme. While all departments should be reviewing deaths of patients in their care, and in anaesthesia this is most usefully done in conjunction with surgical specialties, there is also much to be learned from using a structured approach to all hospital deaths.^{1,2,3,4,5}

Structured mortality review is:

- D useful for identifying patients where escalation of care should have occurred, or been provided in a more timely manner
- D to enable sharing and categorisation of harm events, and development of themes – such as end of life care
- D to allow trends to be seen over time, e.g. failure to communicate amongst teams
- D to gain information to improve end of life care.

To do a structured mortality review, a standard tool, the mortality matrix is available from the websites of the NHS institute or the Institute for Healthcare Improvement.

Figure 1 Mortality 3 x 2 matrix

Place of death	Intensive Care	HDU	Ward
Admission for terminal care			
Yes	A	B	E
No	C	D	F

Fifty sets of randomly selected notes of patients who have died in a set time period are examined twice a year; e.g. 50 sets of randomly selected notes of patients who died in June and December. The deaths are examined according to a proforma and placed into categories of ICU/HDU admission yes or no, and for terminal care, yes or no (Figure 1). This allows the identification of patients whose care, in the opinion of the auditors, should have been escalated to a higher level.

The final admission of these patients is also analysed using the global trigger tool, a validated widely used tool for measuring patient harm.⁶

From the matrix above the care of patients in category F, for active treatment who did not die in a critical care bed should be examined closely. The matrix also allows examination of issues around the use of critical care beds (categories A and B) and the admission of patients from the community who are at the end of life (category E).

Mortality reviews offer a means of 'saving lives by studying deaths'⁴ and the same themes come up time and again from different hospitals worldwide.^{1,2,3,4,5} The commonest of these are:

- D failure to recognise, record and to react to the deteriorating patient
- D failure to plan
- D failure to communicate
- D hospital acquired infection
- D renal failure
- D post-operative complications.

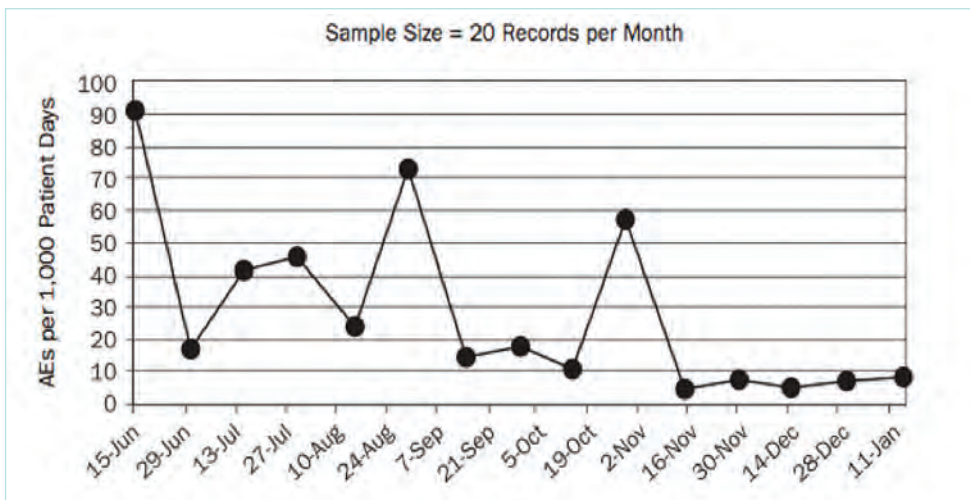
Hospitals can also develop their own standardised mortality review proforma to ensure that data and themes are collated from all deaths. Examples can be found on the web such as that from the Royal Berkshire NHS Trust.⁷

Trigger tools can be used to identify adverse events and areas for improvement by auditing small samples of all patient notes, for all in-patient admissions, not just those who died. Triggers such as the use of naloxone are used to detect potential harm, which in the case of naloxone use would be overdose of opioid. Presence of a trigger does not necessarily mean that the patient came to harm. 'Harm' is classed as something you would not wish to happen to you or to a relative. Harm is divided into categories, the more severe of which are:

- D E: temporary harm and required intervention
- D F: temporary harm to the patient and required initial or prolonged hospitalisation
- D G: permanent patient harm
- D I: patient death.

This method is again used to classify harm into themes as suggested above and to identify areas for improvement. It can also be used to track reduction in harm associated with improvements in the quality and safety of care (see Figure 2). Harm free care can also be assessed using the 'NHS Safety Thermometer'.⁸ For more detailed information on how to use global trigger tools for audit and quality improvement see the websites of the NHS Institute for Improvement and Innovation and the Institute for Healthcare Improvement.^{1,2,9}

Figure 2 A run chart showing reduction in patient harm over time as a patient safety programme is implemented. AE = adverse event. 90 harms per 1,000 patient days is approximately the norm before a programme is in place.



All hospitals in the UK submit data to receive a standardised mortality ratio (HSMR); in English and Welsh hospitals this is done using Dr Foster¹⁰, a company partly owned by the Department of Health and providing statistical support through Imperial College. For common diagnoses and procedures Dr Foster will calculate observed to expected death rates to provide the HSMR and also relative risks for that procedure or diagnosis in your hospital, compared with other hospitals. This can be a source of useful data on which to base an audit or quality improvement project, as this data is already collected by your hospital. The business analysis unit in your hospital should be able to help you with this.

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- 10 <http://www.drfoosterhealth.co.uk/>

10.

Checklists in anaesthesia: key points

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We all use checklists in our daily lives, ranging from the humble shopping list to essential checks when authorising our Paypal payments. Checklists may be presented in different formats and are used in a variety of ways. For instance, the tick box 'tickets, money, passport' helps us remember easily forgotten items during times of distraction, but 'can I see your passport sir?' acts as a barrier that determines further progress. Checklists have been used in industry for many years, and were introduced as a consequence of increasing complexity of procedures and processes, beyond the ability of any one individual to remember. Complexity is part of modern clinical practice – checklists have been shown to improve outcomes in clinical care and are now becoming standard of care in surgical practice.¹

Checklists may be a series of 'read and do' checks, like checking the anaesthetic machine; challenge and response checks to make sure that routine procedures have been completed, or they may be a series of prompts that structure a team briefing or debriefing.² They may be used to address key safety items that are frequently overlooked, to standardise performance of clinical tasks, or to facilitate communication, shared understanding, or handover of essential information within or between clinical teams.

The science behind checklist development is complex, and many lessons have been learnt from industry.² A good checklist should be:

- D evidence-based, trialled and tested before introduction
- D focused to deal with a particular set of issues/tasks
- D should only contain 5–9 items in each section
- D should prompt communication and confirmation of information
- D should be clearly designed, using familiar language and clear fonts.

The WHO Surgical Safety checklist addresses key points in peri-operative care during the sign-in, time-out and sign-out, that if omitted, substantially increases the risk for the patient. The WHO checklist and other surgical checklists have been found to improve surgical morbidity and mortality in a range of settings,^{3,4,5} but the impact of the WHO checklist is crucially dependent on compliance.⁶ Adoption of the checklist improves safety attitudes of theatre teams, and if questioned, clinicians would want a checklist to be used if they were undergoing surgery themselves.⁷ Pre-list briefings and debriefings substantially improve communication in theatre, reduce list inefficiency, wasted equipment and improve morale. The use of the WHO checklist is mandated in England and Wales, and it is recommended that it be combined with briefings and debriefings for maximum impact.

Implementation of a checklist, pre-list briefings and debriefings is a complex process. This requires training, understanding 'why', coaching and feedback. Local champions and leadership are key, with support from senior management in the organisation. Unfortunately, all too often checklists are developed that are lengthy, complex and time consuming, and there is little attention to implementation. Simple measures of completion are useful during introduction, but they should not be the only focus. Simple measures could include:

- D compliance with pre-list briefings (including who was present)
- D compliance with the three key stages of the WHO checklist
- D compliance with individual items on the checklist
- D completion of safety attitude questionnaires by members of the theatre team
- D compliance with key items of care; antibiotic prophylaxis, warming, thromboembolic prophylaxis
- D surgical site infections
- D critical incidents
- D 'glitches' and delays in the theatre list
- D surgical morbidity and mortality

Where now for checklists? Checklists are common in ICU, they are used to facilitate handovers and are included in care bundles to reduce central line infections and ventilator associated infections.¹ Checklists improve performance in anaesthesia crises by facilitating decision-making and ensuring adherence to emergency protocols.⁹ Checklists are here to stay but the challenge will remain:

- D Can we design checklists effectively?
- D Can we adopt and use them effectively?
- D Can we improve clinical care?

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11. Development of a checklist: the pre-intubation checklist for out-of-theatre intubation

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Why develop a checklist?

As healthcare becomes more complex and outstrips our ability to remember and reliably deliver all critical components of a task, especially when working with different teams and in difficult situations, simple checklists have been designed to improve reliable delivery of key steps. Checklists remind us of minimum essential process components and make them explicit; in addition the use of a checklist instils a discipline of performance as well as verification.¹ The need for, and utility of, a checklist in a particular clinical situation must be tried and tested under a variety of conditions before it is implemented into clinical practice.

The development of a checklist for a critical clinical situation is described below as an example of how an effective checklist was developed, and to serve as a prompt for departments to develop their own checklists.

Why develop this checklist?

Patients may be intubated outside the operating theatre for a variety of reasons. The common factor is that many will be physiologically unstable, and in locations which are not routinely used for airway management. As a result, complications are observed more frequently during out-of-theatre intubation than during airway management in theatre.

Airway management should be performed to the same standard regardless of location, however, guidelines are inconsistently followed outside the operating theatre.² NAP4 has demonstrated harm associated with failure to use capnography during airway management in the Emergency Department and Intensive Care Unit.³ Reasons for the failure to follow guidelines include the absence of skilled assistance, and unfamiliarity with the environment.

We sought to develop a simple, cost-neutral solution to improve use of capnography, and compliance with other guidelines. A checklist was developed to remind staff less familiar with airway management of requirements for intubation, and to act as a prompt for experienced providers working under pressure and in unfamiliar environments.

Best practice: research evidence or authoritative opinion

In 2009, the Association of Anaesthetists of Great Britain and Ireland published a statement recommending that capnography be used in all patients whose tracheas are intubated, or whose airways are maintained with supraglottic airway devices anywhere in the hospital.⁴ In the same year, the Intensive Care Society also published a guideline recommending the use of capnography during tracheal intubation in the Intensive Care Unit.

The Difficult Airway Society has published algorithms for the management of the unexpected difficult airway.⁵ These include the use of, at various stages, a bougie, alternative laryngoscope, LMA or iLMA, and equipment to perform cricothyrotomy. The presence of this equipment should be regarded as mandatory for safe airway management.

In 2010, Jaber et al demonstrated that the rate of severe complications associated with intubation on the Intensive Care Unit could be significantly reduced by the use of an intubation care bundle.⁶ This bundle included:

- D presence of two operators
- D fluid loading pre-intubation (in the absence of cardiogenic pulmonary oedema)
- D preparation of long-term sedation
- D pre-oxygenation with non-invasive positive pressure ventilation
- D use of ketamine or etomidate and suxamethonium during rapid sequence induction

- D confirmation of tracheal tube position with capnography
- D noradrenaline for post-induction diastolic blood pressure < 35mmHg
- D initiating long-term sedation immediately after intubation
- D use of lung protective ventilation.

Checklist development process

We sought to develop a checklist that would:

- D improve compliance with evidence or expert opinion-based guidelines
- D potentially reduce complications associated with out-of-theatre intubation
- D support junior anaesthetic staff in preparation for intubation
- D remind non-expert support staff of their role during induction and intubation
- D be a useful prompt for senior anaesthetic staff
- D not delay emergency induction.

To achieve these aims, our group (RTIC Severn, a group of trainees with an interest in Intensive Care Medicine) developed a draft checklist, and refined it through a series of short PDSA cycles. The initial checklist was trialled by the group at the hospitals in the region. To study the effect of the checklist, feedback was actively sought from both the intubator and assistants, and then fed back to the group. This feedback was collated to plan the next iteration of the checklist. After eleven development cycles, no further significant improvements were suggested, and the checklist was regarded as finished.

To confirm the effectiveness of the checklist, a before and after audit of capnography use during out-of-theatre airway management was conducted. Before introduction of the checklist, capnography was used in 67% out-of-theatre intubations, compared with 100% of intubations when the checklist was used.

The checklist is available at <http://www.saferintubation.com>.

This article has been written on behalf of the RTIC Severn group. This is a group of junior doctors with an interest in intensive care medicine and patient safety. Involved in this project were: Andrea Binks, Tim Bowles, Hamish Breach, Michelle Chopra, Sara Cook, Nick Dennison, James Dunn, Dan Freshwater-Turner, Miguel Garcia-Rodriguez, Gareth Gibbon, Subbu Halder, Clare Hommers, Katie Howells, Rob Jackson, Andrew Jacques, Dom Janssen, Abby Lind, Nina Reeve, Kieron Rooney, Sarah Sanders and Anoushka Winton.

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12. Quality indicators in peri-operative care

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Introduction

Quality indicators for peri-operative medicine may be considered in the 'structure-process-outcome' format first defined by Donabedian in 1966,¹ and outcome measures may be either subjective or objective. Systematic review has listed quality and safety indicators of relevance to anaesthetists which have been implemented in healthcare systems across the globe² and include:

- D Structure:
 - ◆ nurses having received training in acute pain management.
- D Process:
 - ◆ use of intra-operative warming devices.
 - ◆ measurement of blood glucose levels in diabetic patients in accordance with hospital protocols.
 - ◆ documentation of appropriate antibiotic or thrombo-prophylactic medications.
- D Outcome:
 - ◆ post-operative thrombo-embolism
 - ◆ post-operative 30-day mortality
 - ◆ peri-operative central venous catheter infection rate.

Structure and process indicators

NICE guidance, and a number of reports from NCEPOD, the Department of Health and other organisations have recently highlighted a number of areas in peri-operative medicine where structure and process vary between Trusts and therefore outcome is also affected. These include:

Pre-operative

- D Pre-operative clinic assessment of high risk patients undergoing elective surgery.³
- D Explanation to patients and documentation of estimated peri-operative mortality risk.^{3,4}
- D Avoidance of unnecessary delays to operating on elderly patients.⁵
- D Formal nutritional assessment of elderly patients undergoing surgery.⁵
- D Involvement of consultants in pre-operative planning for all high risk patients (including emergency/out-of-hours cases).^{3,4}
- D Use of ultrasound to insert central venous catheters: <http://www.guidance.nice.org.uk/TA49>.

Intra-operative

- D Consider use of the oesophageal Doppler monitor in patients undergoing high risk major surgery: <http://www.nice.org.uk/guidance/MTG3>.
- D Consultant delivered care for high risk cases.⁴

Post-operative

- D Provision of Level 2 and 3 care for elderly and/or high risk patients undergoing major surgery.^{3,4,5}
- D Provision of and adherence to guidance on the management of peri-operative pain in the elderly.⁵

Outcome measures

Perioperative outcome measures may be divided into subjective (patient reported) and objective, e.g. mortality and morbidity.

Subjective

There is an increasing drive from central government to record and act upon patient reported outcome; these may be considered in the following categories:

- D patient experience, e.g. the annual NHS inpatient survey, which asks patients about their experience of the environment of care including cleanliness, staff approachability and friendliness, quality of explanations given to them, efficiency of transit through the hospital etc.
- D patient satisfaction, e.g. patient perception of their symptom control, e.g. nausea and vomiting, pain, pruritis
- D patient reported change in health-related quality of life, e.g. Patient Reported Outcome Measures such as the Oxford Hip and Knee scores which are now mandated by the Department of Health for all patients undergoing joint replacement in NHS Trusts.

All of these measures may be used as quality indicators in peri-operative medicine. For example, the NHS in-patient survey has questions relating to the quality of information given to patients about anaesthesia, and the quality of pain control. Patient satisfaction with anaesthesia care may be measured with a variety of tools which have been demonstrated in the literature to be valid and reliable indicators of the quality of peri-operative care (see audit 3.11 on patient satisfaction). While it may not seem intuitive that anaesthesia care can contribute to longer term patient reported outcome, there are numerous studies which demonstrate the impact of anaesthesia-related interventions on complication rates, e.g. oesophageal Doppler guided haemodynamic optimisation, timely antibiotic administration, epidural analgesia) and complications have been demonstrated to have an independent effect on long-term outcome.⁶ Therefore, both the measurement of these patient reported indicators, and importantly, the feedback of this information to clinicians, are likely to contribute to improved short and longer term surgical outcome for patients.

Objective

Mortality and morbidity are routinely measured both by administrative means (hospital coding linking into Hospital Episode Statistics data) and often by clinicians (mortality and morbidity meetings, input into national clinical audits such as the National Joint Registry and colorectal cancer audit).

A concern of many clinicians in the routine reporting of such data to facilitate comparative audit between surgical teams and institutions, is concern over risk-adjustment (or the lack of it); that is, teams who routinely undertake higher risk patients, may have worse outcomes, which may be unjustly attributed to poor technical or team performance.

The p-POSSUM scoring system is the most precise predictor openly available and there are a variety of websites, e.g. <http://www.riskprediction.org.uk>, and apps, e.g. 'surgical risk', freely accessible to enable clinicians to calculate the p-POSSUM score. In addition to enabling clinicians to calculate mortality risk in order to aid peri-operative management, routine use of such systems would enable departments to report the predicted risk of the patients receiving care, so that outcomes audit might become more meaningful and reliable.

A number of national clinical audits related to peri-operative care and which measure objective patient outcomes as well as a number of structure and process indicators, are included in the Department of Health's Quality Accounts process. These include the National Hip Fracture Database, the NCEPOD audits, the adult cardiac surgery audit and the soon to begin Emergency Laparotomy Audit. More details of this can be found at the Healthcare Quality Improvement Partnership website (<http://www.hqip.org.uk/national-clinical-audits-for-inclusion-in-quality-accounts/>).

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13. Performance polygon: a method for representing multi-dimensional performance data

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Measurement of healthcare outcome is central to assessing quality and quality improvement. Its importance is increasing as a strategic focus of the Department of Health and for medical revalidation. Although healthcare performance is often presented in a single dimension, e.g. a 'post-operative pain audit', healthcare quality is more complex and often involves several related or conflicting outcomes, e.g. for tonsillectomy measures of quality include time taken for anaesthesia or surgery, time in theatre, blood loss, post-operative nausea and vomiting (PONV), pain, day case rate, hospital episode cost, % readmissions and % re-operations for bleeding, duration of post-operative pain and patient's time off school or work. The surgeon's focus (operative time, bleeding, readmission rate), the anaesthetist's (nausea, pain, day case rate), the theatre manager's (total theatre time, cost), the hospital management's (cost, day-case rate) and the patient's (pain and nausea, readmission rate, time off school or work) may all differ.

Relying on single outcome measures encourages 'silo mentality' and changes in practice intended to improve one outcome, e.g. pain on waking, may adversely impact others, e.g. PONV, time in recovery. When trying to improve one aspect of care, 'balancing measures' should also be recorded to allow unintended consequences to be considered. The use of performance polygons provides a visual prompt to consider a variety of factors which impact on the measurement of the quality of care.

We introduce 'performance polygons' as a form of data representation reflecting the complexity of outcome measures. Examples are shown but we do not intend to define which outcome measures should be used when measuring anaesthesia (or other) quality; the NIAA and RCoA working Group on Quality Measures in Anaesthesia is addressing this.

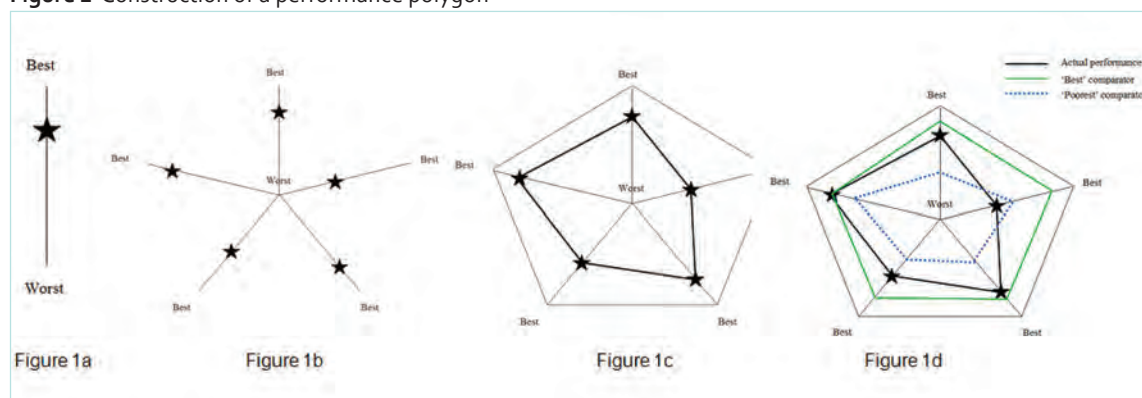
Performance polygons

Performance polygons qualitatively represent multidimensional data making understanding of overall performance easier. They are derived from star charts, first proposed by Georg von Mary's more than 100 years ago.

A performance polygon is constructed as follows (see Figure 1).

- D An outcome measure is plotted on a single line.
- D Additional measures are added as equally spread 'spokes' spreading outwards from same origin (four measures 90°, five measures 72° etc).
- D Performance data is plotted and the points joined forming a 'performance polygon'.
- D Comparator polygons are superimposed as benchmarks.

Figure 1 Construction of a performance polygon



Comparator polygons can be internal, e.g. temporal changes in an individual's multidimensional performance, or external, e.g. pre-defined benchmarks, and may be used to represent the performance of individuals or groups, e.g. theatre team, hospital, whole healthcare organisation.

Examples are given here.

A Comparison with departmental performance.

Figure 2 shows an individual anaesthetist's performance with exemplar outcome measures recorded in recovery. Chosen outcomes are of interest to patients, surgeons, recovery staff, managers and anaesthetists and include measures of anaesthetic skill (regional block success), process variables (adherence with good prescription practice), efficiency measures (turnaround time) and patient-relevant outcomes (pain, PONV): all measures of anaesthetic performance. The comparator polygons here are the 5th and 95th centile of a reference group, (e.g. the whole anaesthetic department).

This anaesthetist's outcomes are a mixture of above average and very good (compared to the reference group), but (s)he slow. Criticism about slow service may be deflected by the high quality of patient-relevant outcomes. The anaesthetist might focus on improved turnover with maintenance of outcomes.

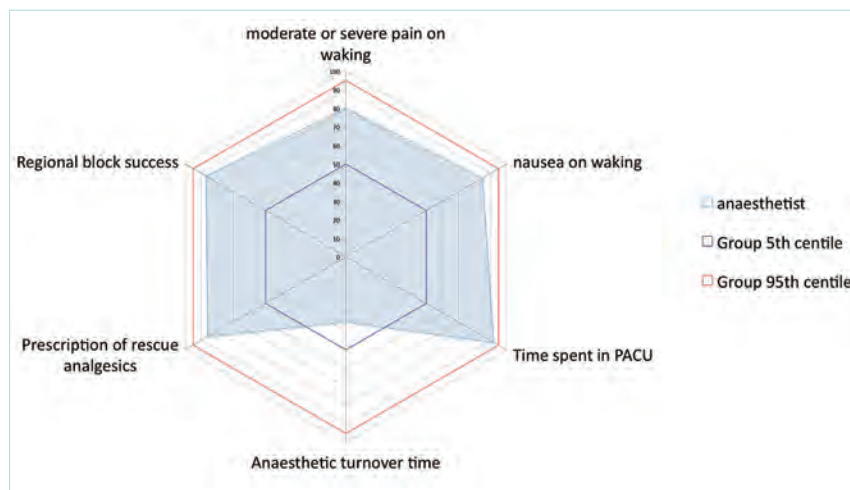


Figure 2 Performance polygon; individual anaesthetist's performance with 95th and 5th centiles as comparator.

B Comparison with own performance.

Figure 3 uses the same outcome measures to compare with historical performance (previous year's best and worst months). A large polygon suggests improved outcomes but at the cost of turnover speed. This anaesthetist has increased use of ultrasound for regional anaesthesia and remains on a learning curve. If scrutinised by a 'pain audit' they would be considered to be performing well, but an 'efficiency audit' might raise concerns. The multidimensional data allows a balanced assessment. Re-plotting after a suitable interval will show whether the good outcomes are maintained with improved speed.

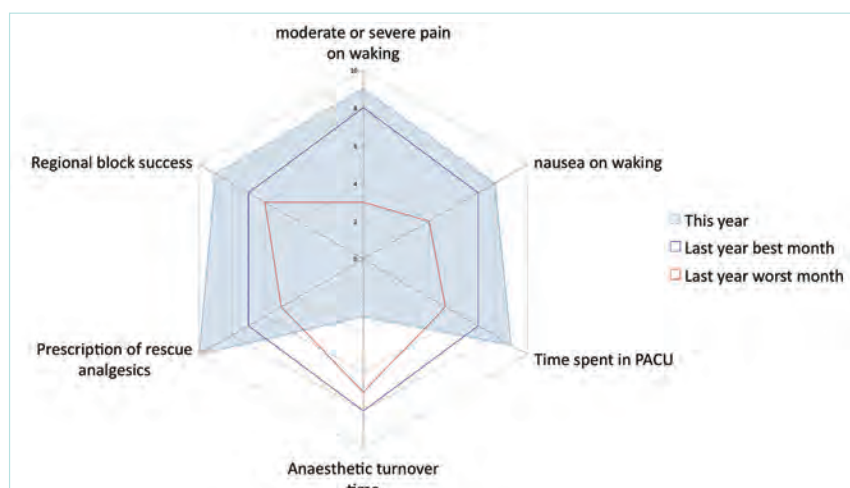


Figure 3 Performance polygon: individual anaesthetist's performance compared to own historical performance.

C 'Rank' as comparator.

In Figure 4 using the same outcome measures departmental ranking is used as comparator for each outcome (9th, 5th and 1st decile). This polygon is small with low scores in several domains indicating overall 'relatively' poor performance. This anaesthetist ranks poorly in their department on most measures but has rapid turnover. Perhaps despite a happy surgeon, the anaesthetist might reflect on a need to slow down and do better!

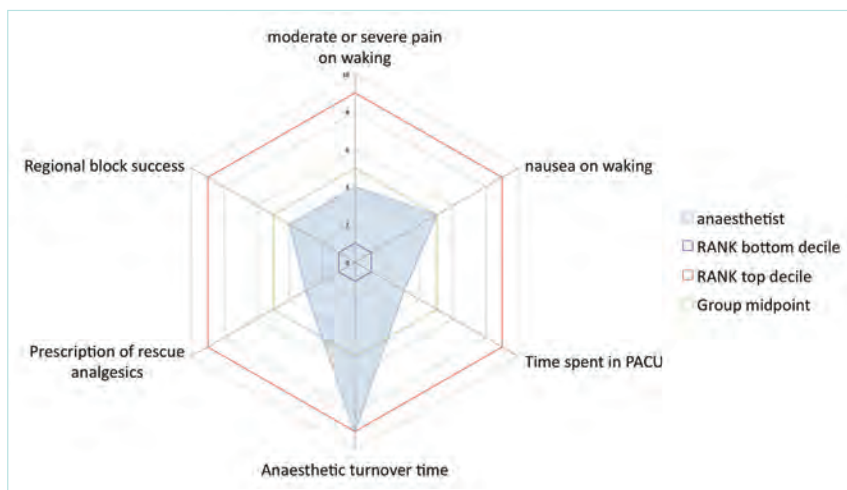


Figure 4 Performance polygon with rank as comparator.

D Comparison with a 'benchmark'.

In Figure 5, the comparators are an upper benchmark of 'good performance' and a lower benchmark of 'unacceptable performance'; perhaps generated from departmental data, published outcome data or consensus opinion. Using external 'benchmarks' overcomes the limitation of using colleagues' performance as a comparator (a whole department may perform well or poorly). Such a polygon might have a role in identifying poor performing trainees or as part of revalidation for trained anaesthetists.

This anaesthetist is quick and generates very comfortable patients who recover slowly with high rates of nausea, compared to the benchmarks. Perhaps this anaesthetist uses excessive amounts of opioids and minimal adjuncts or is not good at, or avoids, regional anaesthesia. A pain audit would rank this anaesthetist highly but recovery staff are unlikely to rate his/her performance as good.

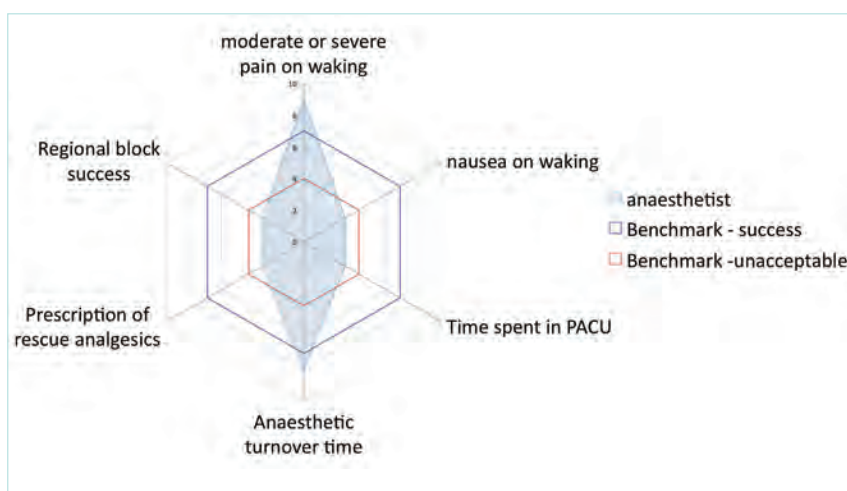


Figure 5 Performance polygon: individual anaesthetist's performance with 'benchmark' comparator.

E Surgical team performance

Performance polygons need not be restricted to anaesthetic practice. Figure 5 shows multidisciplinary multi-dimensional outcomes after knee arthroplasty. The EQ5D measures global well-being in five health-related domains and is used in healthcare outcome studies. The comparator polygons are 95th and 5th centiles and median performance of a reference group: which might be historical data, performance in the neighbouring theatre, a neighbouring trust or nationally acquired data.

All outcome measures are of interest to all team members but individuals may influence some outcomes more than others: anaesthetist (theatre time, time to mobilise and EQ5D score), surgeon (theatre time, complication rate and Oxford knee score), nursing and physiotherapy care (time to mobilise, EQ5D score and length of stay). Managers will be interested in the time in theatre and length of stay and the patient, most importantly, will likely be most interested in EQ5D, length of stay and Oxford knee score. Other outcomes of interest may be added or substituted to creating a polygon with a different focus.

The quality of performance is high, with excellent three month outcome: using the polygonal data the team might address those measures which are closest to the median and turn length of stay from good to excellent.

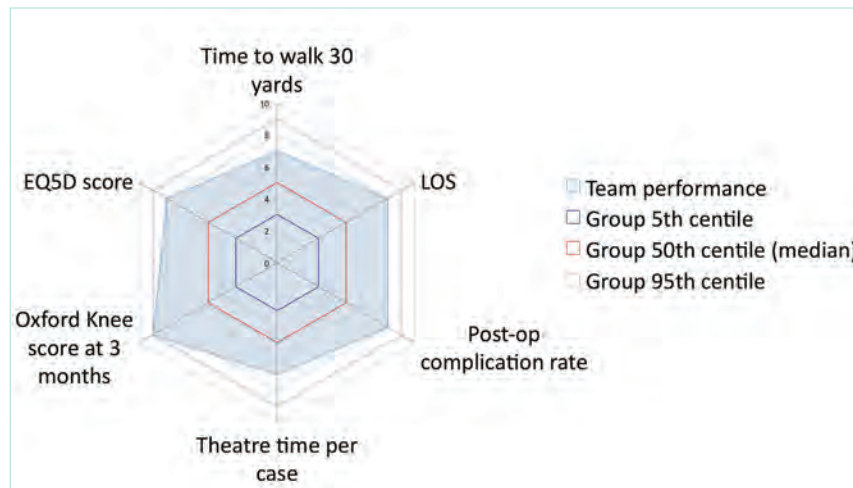


Figure 6 Performance polygon: surgical team performance for total knee arthroplasty.

A performance polygon such as this might be used to compare surgical or anaesthetic practices. For instance during debate about the best surgical or anaesthetic/analgesic method to use for knee arthroplasty a performance polygon might provide a more rounded assessment of the utility of different techniques than the traditional approach of a pain audit. Introduction of an enhanced recovery programme could lead to comparison of performance polygons before and after its introduction: focusing not only on length of stay but also the impact on other measures of quality, allow a balanced assessment.

Comment

Performance polygons might be used in a department as a useful starting point for an appraisal, to examine an individual's performance in the event of a complaint, and for revalidation (capturing data for 4 of the 6 types of supporting information required for revalidation domains: i) colleague multi-source feedback ii) patient multi-source feedback iii) clinical outcomes data iv) evidence of clinical audit and quality improvement). If a database is large enough performance polygons might be used to examine team or individual performance for specific operations to determine perhaps who performs best (so they may educate others) or whether any individual is a lower outlier (so they may learn from others). If used continuously, capturing data from all anaesthetics, performance polygons would become increasingly valid and valuable. Widespread collection of similarly defined data could usefully contribute to national benchmarking; a process already being developed in the USA. Clearly the applicability of performance polygons need not be limited to anaesthesia but is suitable for examining other spheres of medicine. Performance polygons also have a role in representing change such as introduction of new techniques/procedures or in research to show both primary and secondary outcomes. Manipulating comparator polygons and axes length can enhance the value of performance polygons but is beyond the reach of this article.

A final word of caution: the area of the performance polygon may be altered by varying the order in which the outcomes presented and not all outcomes may have the same 'weight': as a result performance polygons are not suitable for quantitative analysis.

Conclusion

Performance polygons are a simple but powerful way to represent data over several domains; they provide a visual representation of data which is easily understood by observers. The use of comparator polygons can enhance their value and transform the polygons from simple graphical displays to a potential driver of change and quality improvement.

Further reading

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14.**Publishing your improvement work**Dr M Daniel,¹ Dr A Longmate²

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The definition of audit includes an evaluation of a specific quality or quantity. There are many examples of possible audits in this book. Improvement involves a change for the better, typically of a process or structure leading to improved outcomes. There is much that can be improved in current medical practice. Sharing what we learn from our improvement efforts is an important part of this work.

All improvement work is a social process, and at heart is the requirement for people to change how they do part of their work. This makes it different from research examining whether one drug or intervention is better than another in some dimension. The typical clinical research uses a study protocol which provides much of the foundation for the methods and sets up the results section. In contrast, improvement work often involves more than one change, and subsequent changes are based on learning gained as the work progressed. This difference has often led to difficulties in getting improvement work published, often as it does not fit the traditional structure used in medical journals: Introduction, Methods, Results, and Discussion (IMRaD).

The Standards for QUality Improvement Reporting Excellence (SQIRE: <http://www.squire-statement.org>) guidelines¹ were published in 2008 with the aim of increasing both the quantity of improvement work published and the quality of the published work. The SQIRE guidelines are now used by many journals. These guidelines function in the same way as the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomised controlled trials. The SQIRE guidelines provide a checklist that would help anyone working on an improvement project frame their work.

There are items on the SQIRE checklist that are worthy of mention in this brief note:

Why did you start?

A good quality improvement paper will describe the information that led to the need to make a change. Do this by first providing a summary of the current knowledge relevant to the topic. Describe the known standard or the current best practice, and how local practice compares with this. This provides a description of the quality gap at the start of the improvement work; it also provides a basis for describing the aim of the improvement project.

What did you do?

Quality improvement work intends to make changes to what is, or was, routine care. Describe what was done, and how these changes were implemented. Include a description of the mechanism by which you thought these changes would have an effect. Changing routine work will be dependent on the characteristics of the setting in which it occurs. SQIRE guidelines make clear that this is an important area to fully describe to enable your reader to determine how a similar approach may work in their own context.

What did you find?

Your data will usually be presented in time series, usually in the form of a run chart. Quality improvement work occurs in the real world, and as such the improvement strategy may change from learning obtained as the data is gathered over time. This is important to record and share. Annotating the run charts to provide a timeline of what changes were made will provide your reader with a true sense of how the work evolved over time. Doing this is more challenging than it sounds. Keep a set of notes as the work progresses, about what you did and what you learned.

The Standards for QUality Improvement Reporting Excellence guidelines provide an excellent resource for designing and writing up an improvement study. The contents of this RCoA document together with ten valuable tips recently provided by an experienced improver² will help you make improvement part of daily work.

Top 10 tips for incorporating scientific quality improvement into everyday work.

Adapted from Goldmann.²

1. Select projects that will really make a major difference to the patients and staff who will participate in them.
2. Set bold clear aims and a timeline for achieving them e.g: 'we will reduce pain scores in patients undergoing knee replacement by 50% by December 31st 2012'.
3. Assemble a multidisciplinary team.
4. Be creative in recruiting experts, e.g. Do you have a colleague with an engineering degree who is good at understanding system improvement?
5. Develop the most rigorous study design possible without disrupting normal work unduly.
6. Do everything possible not to sacrifice data quality and completeness.
7. Use the need to engage in quality improvement for revalidation and CV purposes as a lever to get colleagues engaged.
8. Do not assume that major external funding is necessary to perform credible improvement work.
9. Pay careful attention to the ethics of quality improvement work but design projects that are unlikely to require formal ethics approval.
10. Whenever possible, anticipate possible publication and use the SQUIRE guidelines.

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