Acknowledgements

We wish to acknowledge a considerable debt of gratitude to all the contributors to the earlier editions, 2000, 2006, 2012. It is testament to the foresight of the editors of the first edition, Dr JA Lack, Dr LA White, Dr GM Thoms and Dr A-M Rollin, that, over 20 years on, their original strapline 'continuous quality improvement in anaesthesia' is now more generally recognised in the application of the emerging science of improvement across all branches of healthcare.

Acknowledgements

Foreword

It is my great pleasure to introduce the latest iteration of the Raising the Standards: RCoA Quality Improvement Compendium.

The 'recipe book', as it is colloquially known, has been a popular and valued resource for anaesthetists in the UK and around the world, providing the basis for many departmental audits for over 20 years in its first three editions. This fourth edition represents the step change in our approach to quality, emphasising further evolution from audit for assurance and measurement to audit as part of an improvement cycle.

Anaesthesia has always been at the forefront of the movement to improve safety by developing safer systems. This Compendium makes effective links between quality standards, training and actions that individuals and departments can take to improve care. Each topic links with the GPAS quality guidelines, ACSA standards and curriculum learning objectives. Departments embarking on audits or improvements based on the topics contained here can be satisfied that in addition to improving care for patients, they are also providing good learning opportunities for trainees and moving their department closer to ACSA accreditation.

The topics reflect the full breadth of anaesthetic practice, spanning perioperative care, pain and intensive care, reminding us of the many ways in which anaesthetists influence the quality of care provided to patients. It contains the key national quality projects with anaesthetic leadership and involvement including PQIP, NELA, NAPs, SNAPs, tracheostomy care, opioid deprescribing and perioperative diabetes care. Each of these reports contains recommendations to change practice and I am pleased to see they are brought together alongside suggested actions to help anaesthetists mobilise this knowledge to provide safer and more effective care.

This Compendium is patient centred, with examples of patient co-design, and prompts to include patients' experiences and perspectives wherever possible. I am grateful to our lay committee for their input and particularly Elspeth Evans for her work alongside the editorial team.

This Compendium also represents a huge amount of teamwork. The College is indebted to the legion of contributors who have submitted recipes. Often experts in their topic, each recipe represent the product of many hours researching and summarising the key audit standards into a digestible summary. The content of each chapter of related topics is coordinated by a chapter editor and a quality improvement editor who has often added points on improvement methodology. The 'section A' of improvement methodology provides an excellent resource for those wishing to learn more about improvement science.

I extend my gratitude to the Compendium editors; Professor Carol Peden and Dr. John Colvin, who have been associated with the book for over 10 years, joined in this edition by Drs Carolyn Johnston and Maria Chereshneva. Dr Chereshneva led the development of the book as a HSRC fellow based at St Georges Hospital.

I strongly encourage all anaesthetists, and in particular those in leadership roles responsible for safety and quality, to adopt the standards and recommendations for action in this Compendium. We continually face pressures of changing demographics and increased complexity, often in an environment with workforce challenges and resource limitations. Using improvement methodology applied to benchmarked standards of care, as listed in this Compendium, we can provide safer and ever more effective care for our patients and more rewarding ways of working for our specialty.

Ravi Mahajan
President of The Royal College of Anaesthetists

Foreword

Previous editions of the Royal College of Anaesthetist's Audit Recipe Book have provided a popular manual of audit topics for anaesthetists since the first edition in 2000, with the third edition in 2012 moving significantly towards recognition of formal improvement methodology in clinical practice. In former editions, the emphasis was on the provision of audits, focused mainly on measurement against defined process standards and, in the last edition, supported by a quality improvement methodology section. This edition strives to provide a much more integrated quality improvement approach across all the topic areas. This continues to be supported by a comprehensive section on quality improvement methodology, now updated to include a wider spectrum of improvement methods, reflecting the significant developments across UK healthcare in the adoption of structured improvement training and practice.

Anaesthesia has a long tradition of improving clinical safety and outcomes by continuous critical examination of our practice.[1–3] However, changing the increasingly complex clinical systems in which we work, and making those changes last, is a very difficult task. We need to combine our professional knowledge of what is the best evidence with knowledge of how to implement improvements, to deliver consistent care for the patients we treat. Improvement science takes into account that context is key in delivering best care; what works for one patient population in one hospital, may not be relevant in another.[4] Knowing what constitutes the best care is not enough: we must ensure that delivery is effective.[5] The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) reports provide ample evidence that delivery of evidenced-based care is at best inconsistent and at worst woefully inadequate.[6]

This new edition of the Compendium further integrates audit and improvement, by providing anaesthetists with an introduction to the science of improvement and demonstrates a range of tools which can be used to drive positive patient-centred change.[4] Many anaesthetists and intensivists throughout the UK have now learned improvement methodology, often from participation in one of the national or regional patient safety programmes,[7–10] and through the inclusion since 2013 of quality improvement training and practice in the anaesthesia postgraduate curriculum.[1] As such, the Royal College of Anaesthetists has been a leader in this field, which is further strengthened across the breadth of medicine by the UK Academy of Medical Royal Colleges' recommendation for quality improvement training in all curricula Quality Improvement: Training for Better Outcomes[12] and by the GMC's explicit recommendations in their generic professional capabilities framework.[13]

The Compendium is still in two sections. The first section includes a comprehensive set of chapters on quality improvement methodology, such as the model for improvement developed by Associates in Improvement[14] and taught by the Institute for Healthcare Improvement.[15] While most of the UK safety and quality programmes use this methodology, we acknowledge that other techniques, such as Lean, are in increasing use. This technique is now included in this edition.

It is the intended place of this Compendium to facilitate and strengthen delivery of comprehensive improvement and safety programmes aligned with RCoA professional standards and accreditation. The second section topics have been chosen to reflect key areas of practice relating to quality of service, covering a range of subject areas that now explicitly aligns the topic chapters with the RCoA Guidelines for Provision for Anaesthetic Services[16] and the Anaesthesia Clinical Services Accreditation standards.[17] This compendium links these key RCoA quality initiatives with the training curriculum, which is also aligned to each recipe.

The Compendium supports anaesthetic departments in a programme of continuous improvement, to take the recipes as a starting point for their own programme of work in a way that provides opportunity for trainees and consultants to participate and learn quality improvement methodology. For trainees in particular, this will link with the quality improvement and safety training requirements in the new anaesthesia curriculum.

What is quality improvement?

Quality improvement is a formal approach to the analysis of performance and then the use of systematic efforts to improve it. Improvement comes from the application of knowledge and a thorough understanding of the system you are trying to improve. Key points to consider when undertaking an improvement project are:

- knowing why or what you need to improve (audit will have provided this information, as well as discussions with patients and your team on what they think the priorities should be)
- having a feedback mechanism to identify if improvement has happened (closing the loop)
- developing a change idea that will lead to improvement
- testing a change before implementation, this may lead to multiple cycles of further change
- knowing when you have an effective change that will lead to an improvement
- understanding how the context in which you are working will influence your improvement work
- using change management techniques for the social aspects of change
- planning for spread and sustainability.

It is important to remember that improvement can result from learning from failure, and so testing what works and learning what does not work, is central to successful improvement.

The process of audit, quality improvement and the role of the Compendium

At its simplest level, audit involves systematic collection and analysis of data to drive change in clinical practice. This may be manifest at several levels from large national audit projects through structured hospital and departmental audit programmes to individuals carrying out single projects. Perhaps the simplest form of cyclical examination of practice and change uses the plan-do-study-act (PDSA) methodology to drive small steps of change in practice at a very local level. While all these approaches are valid, the strengths and weaknesses of each have to be recognised. Large national audits may be comprehensive, well-constructed and authoritative, but locally may suffer from lack of ownership and an understanding of how to drive needed improvement identified by the audit into widespread practice. The use of small stepwise changes in practice via application of PDSA cycles may be seen as a small-scale audit loop. The learning from small PDSA cycles can be accelerated by shared learning in collaborative working, an approach used with success in the national and regional patient safety and improvement projects.[18–20]

Revalidation and quality improvement

Revalidation requires evidence from all doctors about their quality improvement activity, which should be 'robust, systematic and relevant to your work'. Quality improvement activity should contain an element of evaluation and action and, where possible, demonstrate an outcome or change. The GMC suggests that quality improvement activity is wider than clinical audit and includes other measures such as review of clinical outcomes, case review or discussion, audit and monitoring of the effectiveness of teaching programmes and evaluation of the impact and effectiveness of a piece of health policy or management practice.[21] We believe that this new edition of the Compendium provides a tool for all of us undertaking revalidation to be able to link audit to improvement.

Patient and relative participation

Patient experience and patient-centred care[22] should be a cornerstone of the modern NHS and, as such, we would encourage the use and further development of patient and family experience audits. The limitations and pitfalls associated with collection and interpretation of patient satisfaction data are increasingly recognised.[23] Conversely, the high value of specific information relating to patient experience is also recognised and we would encourage the use of such data including patient-reported outcome measures in any service evaluation.
We are grateful to representatives of the RCoA Lay Committee, who provided discussion of these aspects documented in this book. We would expect this to be of use in the execution of many of the included topics and in the future design of new improvement projects.

The future, and how far we have come!

Since the third edition of this book, anaesthetic audit and quality improvement has become embedded in what we do as clinicians. We have achieved real change, such as reducing mortality and improving care for some of the patients at highest risk, those undergoing emergency surgery for laparotomy and hip fracture. In this edition, we further recognise the challenges of dealing with an increasing elderly population with sections on delirium and frailty. As anaesthetists, we have always been a major force in critical incident reporting and we would very much encourage continued reporting as part of audit and risk management. We would also recommend a focus on learning from excellence. Whenever possible this should be done locally (to ensure learning within your own organisation) as well as to the national bodies supported by the RCoA. Developments in information technology and electronic data management should be used to assist audit and improvement especially outcome based audit. We would encourage all anaesthetists to use the methods in this book and the basic template to create their own topics or adapt topics to their own particular needs. If these are of general applicability, we would also encourage you to submit them to us (qualityimprovement@rcoa.ac.uk) for consideration in our next update, and we will publish them on the website. The hip fracture database and National Emergency Laparotomy Audit have demonstrated the power of audit linked to improvement and the use by large numbers of us of standardised data collection. We can now learn from comparisons of practice on a grand scale. We would encourage readers to consider other improvement projects which may be found in this book, which could be used on a large scale to create the same momentum for change in important areas of patient care, if enough data is collected. Our next major step as a specialty with a proven track record in improving care and outcomes will be to further improve the value of the care that we deliver by reducing variation in practice and 'getting it right first time'.

While each of the individual topics are of necessity brief, and our thanks to the rigour and discipline of our many authors for this, we have provided opportunity for authors to reference further material of breadth and depth which is accessible through the College website. We hope the fourth edition of this Quality Improvement Compendium will continue to be a useful reference source to specialist and trainee anaesthetists across the breadth of our specialty.

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Editors, fourth edition

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The patient's perspective

Miss Elspeth Evans, Lay Committee, RCoA

Patients expect to receive high-quality professional care when undergoing any medical procedure and will support any initiative to improve and enhance the way in which they are treated. Of course, all patients want to avoid adverse incidents and bad experiences. An audit or quality improvement project offers an excellent opportunity for collaboration with patients.

Good Medical Practice states that doctors should 'work with colleagues in the ways that best serve patients' interests' and 'must take part in systems of quality assurance and quality improvement to promote patient safety'.[1] The College's own Strategic Plan 2018–20212 includes an aim 'to enhance services and ensure better patient outcomes through collaborative and sustainable work on quality improvement'.[2]

So the prompts are there, but what encourages doctors to carry out an audit or quality improvement project? The public understand that doctors are under pressure in their day jobs and may be too busy or too tired to carry out a project during their working day.[3] However, the benefits of doing so can be enormous: improved patient care and collaboration, cost savings and improved practice. It can also help with career development by learning life skills essential for successful project management. The College now has a network of quality improvement regional leads with suitable experience, who can offer advice and support to those beginning a project. It could also lead to a doctorate or master's degree. In short, these are some of the many strong reasons why quality improvement learning, thinking and practice should be recognised and valued as an integral part of the day job.

It is not necessary to experience anaesthesia personally to be a good anaesthetist, but patients have their own experiences, which they can contribute to a project. The Sprint National Anaesthesia Project (SNAP-1) results showed that 94% of patients surveyed would recommend the service to others: that means there is 6% area for improvement.[4] Undertaking a project will mean managing your time and that of your team, leading change management, dealing with resistance to change and communicating well to win people over. The recipes in this book provide tools and ideas to start the project, collect data, analyse results, decide whether changes are required, implement change and communicating learning to multidisciplinary colleagues. Leading on change may be the most difficult part of a project. Most people are resistant to change due to uncertainty, although most of us at some time, have probably thought that "I wish I'd done that years ago'.

Nudge theory encourages small but significant changes in behaviour. The auto-enrolment pension scheme and the opt-out organ donation scheme set to come in 2020 are good examples of this theory; both assume that most people will not opt out. Another example is a doctor offering a patient a choice of two options for treatment. The Choosing Wisely campaign encourages patients and doctors to make better decisions together about treatments and to avoid unnecessary medical procedures that may not benefit the patient.[5] This is shared decision making to improve patient safety.

The Getting It Right First Time programme is designed to improve the quality of care within the NHS by reducing variation and sharing best practice.[6] The College's own Perioperative Quality Improvement Programme and perioperative medicine initiatives have similar aims.[7,8] The College's report A Teachable Moment: Delivering Perioperative Medicine in Integrated Care Systems offers a number of innovative and award-winning programmes in hospitals across England that are improving patient care before, during and after surgery.[9]

In May 2019, the College launched the Centre for Perioperative Care (CPOC), bringing together a range of healthcare professionals with representatives from a number of medical royal colleges, including surgeons, general practitioners, physicians and nurses.[10] CPOC will be a vehicle to develop and share best practice in perioperative care across the NHS and internationally that contributes to improvements in patient care and safety.

The worldwide need to deliver value in health care through improving quality while considering cost needs more effective ways of working, both for the health service and for patients. Undertaking a QI or audit project could be your legacy to healthcare improvement. I commend the recipes in this book to you.

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Quality improvement in anaesthesia

Edited by Professor Carol Peden, Dr Carolyn Johnston

A1 Getting started on your quality improvement project

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Getting started

We would encourage clinicians to consider the domains of quality: safe, effective, personal, timely, efficient and equitable care,[1] and to choose a balance of audits for assessing the quality of care using structure, process and outcome measures.[2] These audits should sit within a departmental programme or personal portfolio that reflects all the different components of patient care, and should stimulate improvement work when standards are not being met.

How can we make quality improvement as effective as possible?

- Make sure that there is a realistic potential for improvement, and that the end result is likely to justify the investment of time and effort involved.
- Make sure that you have the necessary will, political support and 'muscle' to act upon what you find.
- Examine an area of practice where you have influence (eg the use of nerve stimulators to reverse muscle relaxation) is likely to be easier to influence as an anaesthetist than the quality of consent by the surgical team.
- Make sure that the issue either occurs relatively frequently or is significant when it does occur. This will help to get results that matter.
- Discuss your proposed standards or targets, many of which will be derived from national recommendations and guidelines with your colleagues to ensure that they are relevant and achievable in your local context.

Data collection

- Consider sample size. Effective local quality improvement projects require consideration of what measurement strategy and sample size is really needed to rapidly identify a problem and to begin the improvement process.
- The sample size for audit should be small enough to allow for rapid data acquisition but large enough to be representative. If the data acquisition time is too long, interest will be lost and data completeness will often suffer (eg for an audit of the adequacy of intraoperative fluid documentation consider examining a small sample, such as 10 sets of notes). If a problem is found in the majority of cases and there is clear room for improvement, ensure that energy is directed into changing how fluid recording is done rather than continuing to audit large numbers of case notes, which will take longer and result in the same finding. A structured sampling strategy will help you to gain the information you need without undue time spent on measurement.[3]
- Prepare a method of collection of data that does not require undue additional work from your colleagues. Remember that in an atmosphere of staff shortage and pressure of work, others may not be as interested in your quality improvement project as you are. Any paperwork should be simple and self-explanatory. Wherever possible, aim to take data from existing charts.
- Think about using data that are routinely collected elsewhere. Discussions with clinical coders or hospital business information or analyst teams may help you to find a data source you can use.
- Once under way, monitor the quality of the data frequently and ensure that collection is going smoothly by visiting the wards or the recovery room, or by dropping in on the operating list. Thank everyone involved. Provide feedback often!

Moving towards action

- When you have all your data, analyse it and discuss the results with colleagues. Discuss reasons for failure to meet standards or targets. If targets have been met, consider whether they might be tightened.
- For a major improvement project, invite all interested parties, such as ward, theatre, finance or administrative staff, to a meeting. This is the place to get ideas, make recommendations for improvement and set a timescale for review. A focused structured meeting with time for discussion from a wide range of perspectives is very valuable in gaining buy-in and co-ownership, but this must be balanced against creating inertia or logistic delays in getting ahead with the improvement work.
- Identify the changes required for improvement using the model for improvement:
  - What are we trying to accomplish and by when?
  - How will we know that a change is an improvement?
  - What change can we make that will result in an improvement?

- Think carefully about your aim: you may wish to aim to achieve '100%' as your target, but this may demotivate your team if it seems unachievable. You could split that aim into two – for example aim to reach 85% in three months and 90% at six months. You could also describe the aim as a quantity rather than a percentage, to make it seem more real. For example, aim to 'reduce average fasting times to four hours', rather than 'reduce fasting times by 50%'.
- Consider how best to choose and use the data as effective drivers of improvement. Effective measurement for improvement is described in some detail in subsequent chapters.
- While we are all keen to ensure that the best care is given to all our patients, we would suggest caution on the use of targets of 100%. A 100% completion is great in an ideal world, but there are always exceptions and as such goal can seem unattainable, it can sometimes discourage working towards high reliability.
- Start to make small tests of change and continuously evaluate success or failure until your changes are stable and ready for implementation.
- Ensure that the majority of time in a meeting is not spent on describing the problem; positive patient-centred change requires time for solutions.

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A2 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 error, preventing harm and working as part of a multidisciplinary team all contribute to the disciplines of safety and anaesthesia.

Patient safety has made great progress since the Patient Safety First Campaign.[1] However, harm still occurs and the potential remains to save many lives a year, particularly those of older patients.[2] There were five specific interventions in the Patient Safety First Campaign; leadership for safety, reducing harm in perioperative care, reducing harm from high risk medications, reducing harm from deterioration and reducing harm in critical care. The first intervention recognised the importance of strong leadership to foster a safety culture. The next two interventions, have seen major change in the world of perioperative medicine, with implementation of the World Health Organization Checklist,[3] 'Stop Before You Block' campaign,[4] and the introduction of NRFit™ type connections for neuraxial procedures.[5] Other interventions, such as reducing ventilator-associated pneumonia and central venous catheter-related bloodstream infections, as well as implementation of National Early Warning Scores have led to measurable improvements in patient care. Bundles, processes and checklists are all now terms familiar to practising anaesthetists. Many of these concepts arise from improvement science.

The NHS Patient Safety Strategy of 2019 has three aims, designed to improve patient safety culture and a patient safety system:[6]

- Improve understanding of safety by drawing intelligence from multiple sources of patient safety information (insight).
- Equip patients, staff and partners with the skills and opportunities to improve patient safety throughout the whole system (involvement).
- Design and support programmes that deliver effective and sustainable change in the most important areas (improvement).

The latter aim has a specific target that will require anaesthetic involvement, namely, to reduce neonatal and maternal death and neonatal asphyxia brain injury by 50% by 2025. All of the NHS Patient Safety Strategy aims require a system-wide approach and use of the principles of improvement science. Some of us trained in medical research based on testing hypotheses with randomised controlled trials may struggle to understand where translational science fits in and question its scientific basis. However, many of the improvement and measurement techniques now mainstream in healthcare, have been widely used in industry, agriculture and aviation for decades.

The 'father' of improvement science is William Edwards Deming (1900–1993), an American mathematician, statistician and business consultant.[7] He is credited with improving industrial production in the United States during the Second World War, although is perhaps better known for his work in Japan from the 1950s onwards. He was mentored by Walter Shewhart, a statistician who 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 was credited for transforming the Ford Motor Company from failure to the most profitable American car manufacturer at that time.

Deming's work shows that the processes used in improvement science are not only firmly based on statistical science but have been tested and shown to work successfully in different complex settings. In addition to statistical process control methods, Deming used a technique which he called 'profound knowledge' to examine and diagnose a system This process involved four parts. First, an appreciation of a system as a network of interdependent components with a common aim. Second, a knowledge of variation, a key to understanding measurement including run charts and control charts. Third, a theory of knowledge, what theories drive the system? Lastly, a knowledge of psychology, understanding the human side and motivation of change.

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 individuals in an operating theatre behave, and the culture of that theatre, are integral to understanding how to make that theatre safer. To improve quality we must understand how 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 piece of equipment, rather than organisational aspects. These same technical innovations often prove frustrating, with the realisation that promising innovations make little or no difference to our patients' outcome or that the evidence is not as robust as first promised.[8] Changing how the operating theatre environment, the work flow and the care pathway function may provide a much greater opportunity for improvement than changing technical aspects, such as which new drug or monitor to use.[9,10]

We cannot improve something until we understand it. To understand how we make care safer, more effective and person centred, we must closely examine our microsystems using Deming's 'lens of profound knowledge'. A system is defined as 'an interdependent group of items, people, or processes working together towards a common purpose. 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'. The first step, therefore, to improving a system is to examine it closely, defining boundaries, temporal components and understanding successes and defects within it. To improve our system we must study and diagnose it, much as we do with patients. The science of improvement is not a threat to evidence-based medicine. To the contrary, it complements it, making it easier to make changes that will result in safer, more effective, efficient, equitable, timely and person-centred care.[11]

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A3 Making improvement happen

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So, you've done your audit, looked at your system and identified problems. How do you now make improvement happen? The traditional method has been through education and hard work. While providing training can be necessary and beneficial, on its own it is not enough to achieve change in the complex systems in which we work.[1] 'Every system is perfectly designed to get the results it gets' (Paul Batalden, Institute for Health Improvement). The only way to get real change is to change the system. To do this, you need 'will, ideas and execution'.[2]

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

Improvement methods

A structured approach is needed to drive improvement. There are many models available, including Lean and Six Sigma.[3,4] All these methodologies are derived from the work of Shewhart and Deming. We have included a section in this book on Lean and process maps (Part A Section A4) and we also frequently use the Model for Improvement, a foundation tool used in improvement science, developed by the Associates in Process Improvement (API; Figure A3.1).[5]

The API Model for Improvement includes the simple plan-do-study-act (PDSA) cycle (which you may also see referred to as the plan-do-check-act cycle). This model uses small, rapid-cycle changes designed to test, measure impact and test again.[5,6] This method uses small frequent samples to drive change in a much faster and more proactive manner than the traditional audit cycle. Those of us who have participated in one of the UK safety programmes, such the Scottish Patient Safety Programme,[7] have used this technique. There are three questions central to this model:[5,6]

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

The first question, 'what are we trying to accomplish', gives us our aim (eg we wish to improve outcome for patients undergoing joint replacements). An aim statement needs to be ambitious, but not achievable by hard work alone and should stretch us. A good aim should answer the questions 'How much?' and 'By when', and we advise you to make your aim, specific, timebound, aligned with your organisation and numeric. Thus, a better aim would be: 'We aim to reduce the incidence of acute kidney injury (AKI stage 1–3) for patients undergoing elective hip and knee arthroplasty from 10% to less than 2% by 1 December 2020'.

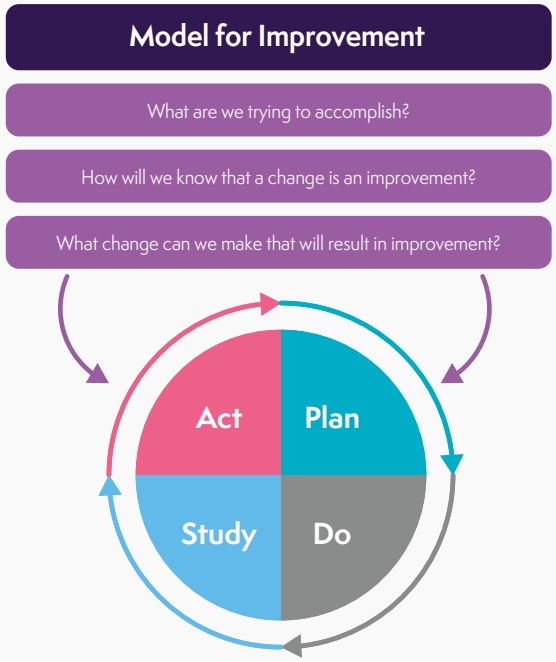

Figure A3.1: Model for Improvement, reproduced from Langley GJ et al, The Improvement Guide with permission of John Wiley & Sons, Inc.

The second question is 'how will we know that a change is an improvement'? For this, we need measures.[8,9] In our example we have a clear outcome measure: a reduction in AKI stage 1–3. To achieve this, we will need some process measures. Process measures measure what we believe we can do to improve outcome, such as screening for high-risk patients (percentage of patients risk screened for AKI) and withholding nephrotoxic agents (percentage of patients in whom antihypertensives are withheld on the day of surgery). Whenever we are changing a system, we must consider how our changes impact other parts of the system. We therefore need balancing measures. For example, if we withhold antihypertensives on the day of surgery, are patients being cancelled because of hypertension?

Once we have our measures, we can start developing our change ideas.[1,5,6] You already have a good idea of what outcome you want to change, but how do you do know where can you make improvements? First, diagnose your system much like you do for your patients. Perhaps you can process map the patient journey and consider where you can most effect change. Do you know of other units that have better outcomes – what do 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 all patients continued their nonsteroidal anti-inflammatories (NSAIDs) right up until the day of surgery and immediately postoperatively, you may develop a change concept aimed at withholding NSAIDs 1–2 days before surgery. Once you have a theory and/or some ideas, you can start to test them. Remember 'all improvement will require change, but not all change will result in improvement'.[2]

Let us say that part of your change package is to withhold NSAIDs 1–2 days prior to surgery. To achieve this, you plan to inform the preoperative nurse and put up a poster in the preoperative assessment clinic. Obviously, you will need to discuss this with the wider multidisciplinary team and have senior support.

Start the PDSA cycle:

Plan: put a poster in the tearoom and inform the charge nurse.

Do this and study what happens. Start to test on a small scale (eg with Staff Nurse Jones and only in Mr Smith's patients on one day). Start your testing with those who are enthusiastic about your idea. If all the eligible patients get their NSAIDs withheld, start testing on a few days. You may then find that the process becomes less reliable, so study why it is now unreliable. You may find that it does not get done tomorrow because the poster is in the tearoom and Staff Nurse Jones forgot because the clinic was busy.

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 (eg use the daily safety brief to highlight the change in practice).

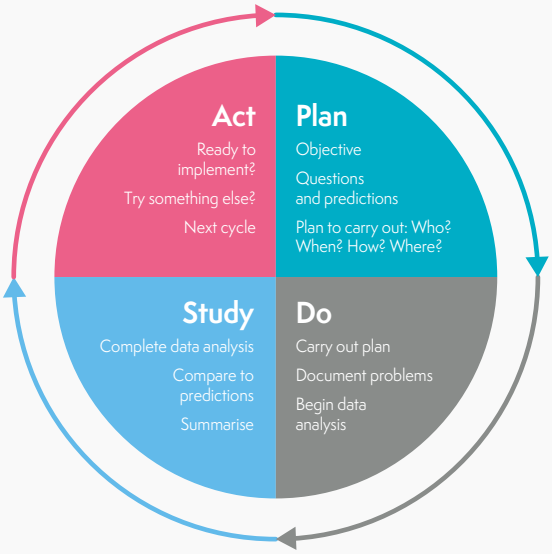

Figure A3.2: Developing and testing a change.

The cycle goes on, testing theories about what works and learning from what does not work (Figure A3.2). If it works during a weekday, does it work on a weekend? Do not assume that your process is reliable until you know it works with different nurses, on different days and with different surgeons. It must work without you being there to drive it.

Finally, while the PDSA cycle may appear to be an apparently new concept, it differs very little from the concept of the differential diagnosis and treatment plan used in medicine. For example, your patient is tachycardic with a normal 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 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.

A3 Making improvement happen

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Quality improvement in anaesthesia

A4 Improvement basics: Lean and process maps

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Lean

Lean is an improvement method developed in Japan's Toyota car factories in the 1980s. For this reason, it is often synonymous with the 'Toyota production system' or the 'Toyota way'. There are multiple versions and terminologies based on the same basic tenets. It was first described in the book The Machine That Changed the World in 1990,[1] and there are now multiple examples of aspects of Lean being used in healthcare. Most notably, Lean tools feature in the NHS Improvement Productive Operating Theatre and Productive Ward titles in the Productive series,[2] as part of the improvement system in Virginia Mason Hospital and now adopted in several NHS hospitals.

Lean consists of an overall philosophy of improvement, focusing on finding value and eliminating waste, by understanding the processes of care, and senior staff supporting 'frontline' staff to solve problems and make improvements. It is associated with several common tools to help staff understand and improve their work.

Seven wastes (or muda in Japanese)

Waste is anything that does not add some value to the patient. An important part of Lean improvement is examining work for sources of waste and then removing them. This concept may include eight wastes, as wasted human potential is often added as an extra source of waste:

- Overproduction: doing unnecessary work, 'just in case' (eg ordering preoperative blood tests on patients with straightforward ASA level 1 outside the National Institute for Health and Care Excellence guidelines or preparing discharge medication packs that are not used).
- Waiting: patients or supplies waiting; there are innumerable examples of this in every operating theatre.
- Transport: any movement of a patient or supplies causes some waste; it is hard to eliminate but you should aim to reduce it (eg patients moving to an inpatient area but being discharged on the same day).
- Unnecessary processing: undertaking a needlessly complex task when a simple one would suffice (eg completing inpatient paperwork for day case surgery).
- Unnecessary motion: this describes staff motion (eg having to visit several storage areas to gather equipment needed for a common task, such as siting an epidural).
- Defects: work that is done with errors; this is a very costly 'waste' as it may ruin the whole process (eg a booking error that results in patient not receiving an admission letter). We could also consider many safety incidents as 'defects' (eg medication errors, wrong site surgery, hospital acquired harm).
- Unnecessary inventory: manufacturers do not store many supplies, instead relying on 'just in time' inventory. In healthcare, excess inventory may result in medications or material that are out of date before use, the need for large storage areas that encroach on clinical space, a cluttered work environment around anaesthetic rooms or hospital beds.

Five Ss

The basic housekeeping discipline of Lean, prominent in the NHS Productive programme, include the five Ss:

- Sort: classify equipment in order of use or importance; remove what is not used (eg resuscitation trolleys).
- Standardise: adopt standard work (eg all anaesthetic rooms/resuscitation rooms sharing a similar layout).
- Simplify: set things in standard locations with labelling (eg shadow boards for rapid sequence induction).
- Shine/scrub: clean and check that everything is working well.
- Sustain: continuing housekeeping audits to ensure that the above steps are followed.

Value stream mapping

Value stream mapping is similar to process mapping.

Gemba

In Japanese, gemba means 'real place' or the frontline of work. Lean thinking emphasises that the solutions to most workplace problems will be found closest to the work; that is, by frontline workers rather than by managerial staff, and so Lean includes 'gemba walks' where leaders or supervisors go to observe frontline work, to 'go see, ask why, show respect'.

Rapid improvement events

As well as promoting continuous improvement, teams may also take time to do 'rapid improvement events' or 'kaizen events' (kaizen meaning improvement). These may take up to a week, where teams set aside time to examine and measure their processes in detail and

rapidly test some improvements. This can be an effective way to make changes when time is short during routine work.

Process mapping

A process map is a graphical representation of a process or patient pathway. It is extremely useful for examining the steps in a process, such as the patient's journey from entering the anaesthetic room to discharge from the recovery room or the steps involved in booking a theatre case. If you are improving a pathway or process, mapping it out can be helpful in a number of ways:

- to look at the overall picture of a process to see where it can be simplified if it is complex
- to see points where the process 'as done' in real life is different from how it was intended in a policy
- to gather team members to talk about the process; this can often be the first time that team members hear about others' perspectives on their shared work
- to look for steps involving any of the seven 'wastes' and try to eliminate them
- to look at the patient's experience of the whole journey.

Process map tips

- Make sure you have all views on the process, including the patient. The more input you have from different roles, the more you will learn about your process
- Define the start and the end of the process you are improving. This can be hard, as most of our processes are interlinked.
- You can list the steps on separate sticky notes and place them in order on a wall or on cards on a table.
- Record how the process actually works, rather than how it is intended to work.
- Go back and examine in detail any steps you are not clear about.
- Add any data you know (eg what percentage of patients complete a certain step, data recording delays between steps).

Variations of process maps

Swimming lanes

This type of process map separates out people or tasks into parallel lanes. This can be useful for complex tasks in which several groups have overlapping or coordinating responsibilities, such as planning an elective caesarean section list. The parallel 'lanes' could list the morning work for the patient, midwife, surgeon, scrub team and anaesthetist.

Value stream mapping

This is a 'Lean' improvement term. It places great emphasis on what steps add 'value' for the patient; for example, eliminating routine follow-up appointments when the patient does not need to attend the hospital.

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A5 Improvement basics: driver diagrams

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Driver diagrams are very useful quality improvement tools. Early in a project the collaborative development of a driver diagram can help to clarify how the aim will be reached through working on different components of the system. Later in the project it can also help to track the various work projects. The creation of a driver diagram should ideally bring a whole team together to brainstorm the things that need to be improved to reach the goal.[1,2] The driver diagram helps to link the changes that you plan to make to the outcomes you want to achieve.[3–5]

If we want to improve care for a particular patient group or condition, then we need to set a clear measurable aim as discussed in section A3: Making improvement happen. What do we want to achieve by when, and how will it be measured? We also need to define the boundaries of the system we are going to work in; for example, are we working in one hospital or across a region? 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 (also sometimes called key drivers) – the key system components 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. There are lots of examples of healthcare driver diagrams on the internet to give you an idea of how to construct one.

You can develop a driver diagram to assist with your own improvement project. Specify your measurable goals in the left-hand box of the driver. For example, I created a driver diagram to improve care for patients undergoing emergency laparotomy (Figure A5.1).[6] The goals are to decrease mortality, complications and cost. To achieve those goals, we need to work on the primary driver areas: preoperative care, intraoperative care, postoperative care and end of life care. If you were a surgeon working on this project you may want to add another driver, such as reduce incidence of patients presenting for emergency laparotomy with a secondary driver 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,

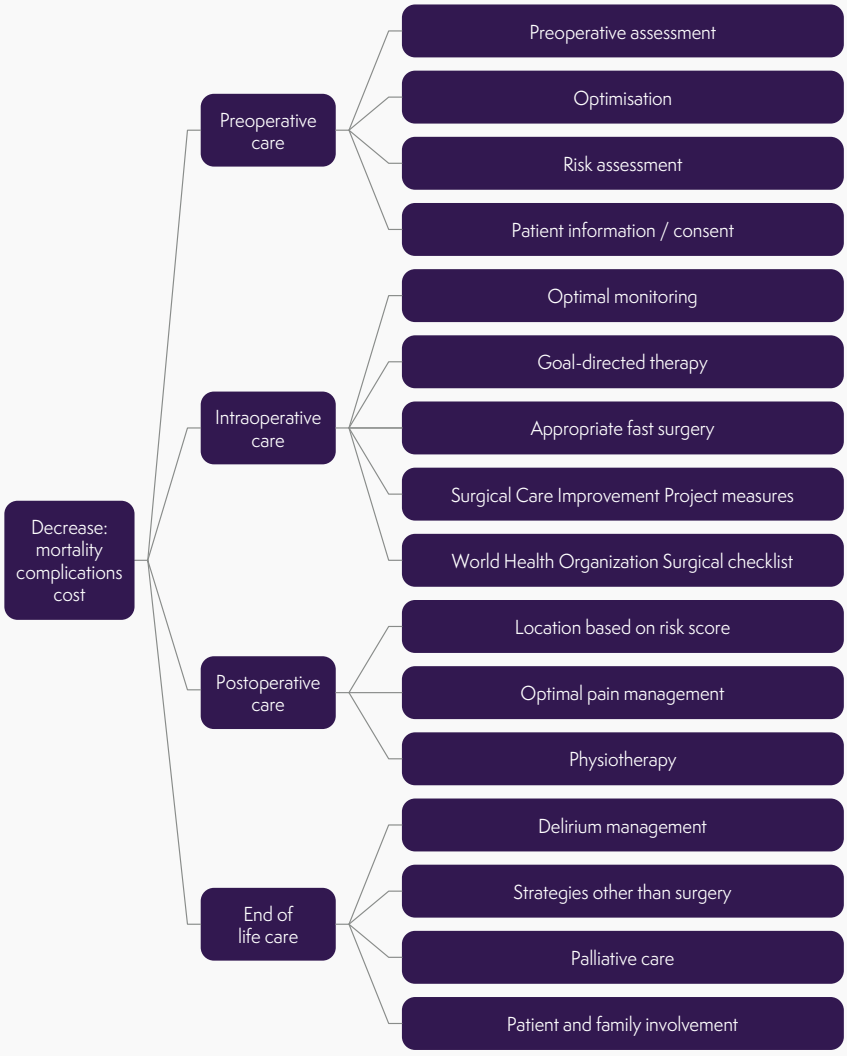

Figure A5.1: Example driver diagram to improve care for patients undergoing emergency laparotomy.[6]

I may want to develop secondary driver components to develop projects to work on the intraoperative care driver. For my diagram, I chose to add the intraoperative projects shown, but you could add others, such as the 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 created your driver diagram with your team, 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.

If you are developing a theory of change for a more in-depth research project or grant, a driver diagram alone may not be enough to connect changes to outcomes; you may need to develop a programme theory.[7] This requires more clarity about why change will happen. For example, saying that 'our new guideline will reduce postoperative nausea and vomiting' assumes that the guideline will work. Stating that 'our new guideline will reduce postoperative nausea and vomiting because it will provide quick access to an evidence-based protocol that clinicians will find easy to use' articulates much more clearly why the guideline will work. When thinking about your improvement ideas get into the habit of thinking through why this idea will work.

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A6 Improvement basics: bundles to improve reliable delivery of care

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The care of the ventilated patient bundle and the central line bundle are all now very 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 they were 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 three to five components of care 95% of the time. Most teams, when they start measuring, will find that their performance for bundle delivery is between 20% and 60%. If you deliver each component of a five-element bundle at 90%, then five multiplied by 90% means that 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 include the use of multidisciplinary rounds and daily goals to reinforce bundle compliance (eg planning the sedation hold for a ventilated patient).

The features of bundle design are as follows:[1]

- The bundle ideally has three to five actions agreed upon by clinicians (each further intervention will reduce reliability, as explained above (eg 7 elements × 90% delivery = 48%).
- The steps are all necessary and each step must be performed to achieve success.
- The multidisciplinary team develops the bundle.
- Elements should be descriptive rather than prescriptive (eg thromboprophylaxis on the ventilator bundle does not define what the prophylaxis should be).
- Each step is individually based on level 1 evidence if at all possible.
- Each step should be clearcut and all-or-nothing. The answer to completion of the step can only be 'yes' or 'no' (eg in the ventilator bundle: Was the sedation stopped this morning? The answer has to be yes or no).
- 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.
- 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 (eg increased reliable implementation of the central line insertion bundle should correspond with a decrease in central line blood stream infections).

Studies indicate that, by using care bundles as part of a comprehensive improvement strategy, clinical outcomes improve.[1–3] 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.

The success of the central line bundle in the United States, after Pronovost and colleagues demonstrated that an intervention including care bundles used in 103 intensive care units 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]

The Surviving Sepsis bundles have demonstrated an association between improved bundle compliance and decreased mortality.[4] The Surviving Sepsis bundle has evolved over time, as more evidence around efficacy and timing has emerged. The newest version simplifies the old three- and six-hour bundles into a one-hour bundle with increased emphasis on the urgency to start treatment immediately when the patient presents.[5] Bundles should be designed to be updated and evolve as new evidence emerges. The simpler and clearer the timing and actions required for high bundle performance, the more likely that bundle implementation will be high.

When designing your own bundle, consider the following steps:[1]

- 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).
- Test with a small sample to identify the barriers to each of the elements in terms of measurement and practicality of implementation.
- When practical elements are identified, move to testing in a single unit or clinical area.
- If clinicians do not choose the individual element about 80% of the time, as you scale up, reconsider or reformat the element.
- Design the bundle with the aim of achieving 95% reliability.

An example of an effective bundle, developed from basics and now being widely implemented, is the emergency laparotomy pathway quality improvement care bundle (ELPQuiC).[6,7] This bundle was developed in one hospital then tested in four, then was scaled up through the Emergency Laparotomy Collaborative programme,[8] and is now being rolled out across England by the Academic Health Science Networks. In both the original ELPQuiC programme and in the Emergency Laparotomy Collaborative, as bundle compliance improved the desired outcome of a reduction in mortality also improved.

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A7 Improvement basics: Pareto charts

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A Pareto chart is used to display data in categories, to demonstrate the most common areas you should aim to improve. Pareto was an Italian economist who was the first to notice what became known as the 'Pareto principle', that 80% of the impact comes from 20% of the causes.

It is a combined histogram (frequency usually displayed on the left-hand vertical axis) and cumulative line chart (usually displayed on the right-hand vertical axis). Using the line chart, you can trace back which categories are responsible for 80% of your impact and so target them for improvement.

As an example, Figure A7.1 shows the reasons for an obstetric list starting late, taken from a daily audit. Looking at the causes that are responsible for 80% of delays, the team should work on blood tests, midwife availability, theatre preparation and patient preparation as key areas for improvement.

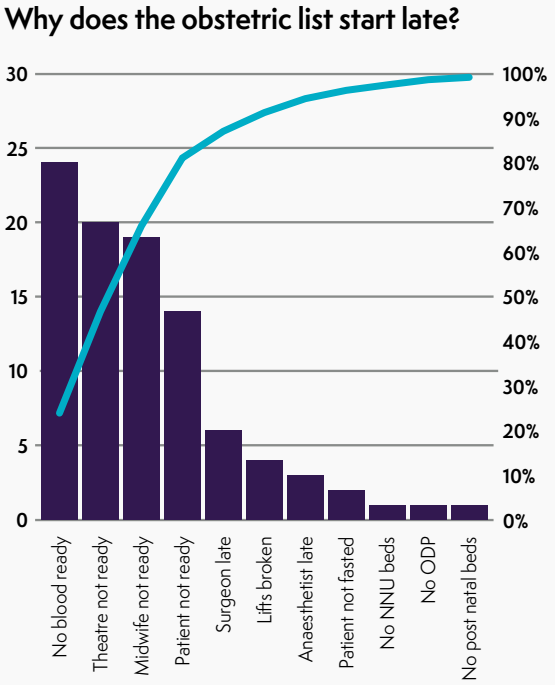

Figure A7.1: Why does the obstetric list start late?

There is a Pareto chart tool on later versions of Microsoft Excel. By entering your frequency data, choosing 'Insert' and then 'Recommended charts', a Pareto chart will be offered as a chart type.

Further reading

NHS Improvement. Pareto chart tool (https://improvement.nhs.uk/resources/pareto-chart-tool).

Quality improvement in anaesthesia

A8 Studying patient harm and death to improve care: structured mortality review, global trigger tool and root cause analysis

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Understanding where harm is occurring in our hospitals is essential to allow us to find the areas for improvement work that will be most effective to increase patient safety. There are a number of tools that can be used to find harm and to help us better understand the underlying causes of harm. These tools include structured mortality reviews, root cause analysis of incidents and trigger tools. It is important to remember that we should proactively look for potential causes of harm, so learning from near misses and using a screening tool such as the global trigger tool should be combined with the learning from mortality reviews and actual harm events.

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. This approach was mandated by the National Quality Board in 2017 in 'Learning from deaths in the NHS' and is supported by the Royal College of Physicians' National Mortality Case Record Review programme using structured judgement review.[1,2]

Structured mortality review helps to identify system issues such as:

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

Mortality reviews offer a means of 'saving lives by studying deaths' and the same themes come up time and again from different hospitals worldwide.[1,3,4] The most common of these are:

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

There is more on structured mortality review in section 4:12 Emergency anaesthesia in this book.

Trigger tools can be used to identify adverse events and areas for improvement by auditing small samples of all patient notes for all inpatient admissions, not just those who died.[5] 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, ranging from temporary harm which required intervention to 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. It is important to be aware that the way in which the global trigger tool is preformed varies between organisations and so it is most useful for internal improvement work and not for comparison of one hospital with another.[6] For more detailed information on how to use global trigger tools for audit and quality improvement see the references below.[4–6]

Root cause analysis is a structured process used to understand how and why an incident occurred or as an investigative tool to understand shortfalls in the quality of care.[7] If the root cause or source is identified, then quality improvement resources can be dedicated to improving care. The link between analysis and action is important and to that end the US National Patient Safety Foundation has coined the term 'RCA2' (root cause analysis and action).[8] A root cause analysis should involve all associated stakeholders through relevant multidisciplinary team involvement, with remedial action planning and associated audit and reaudit to prevent adverse event recurrence.[7] If the adverse event has been significant and a patient harmed, consideration should be given to involving the patient or family in the root cause analysis. It is important to have an understanding of the limitations of a root cause analysis, for example using staff who have not been adequately trained in the technique or failing to involve key stakeholders.[9]

A tool often used in root cause analysis is the fishbone diagram (Figure A8.1), also known as a cause and effect diagram or an Ishikawa diagram (after its inventor Professor Ishikawa who designed it in Japan in the late 1960s). It can be used to help creative thinking and brainstorming on possible causes by the analytic team.[10]

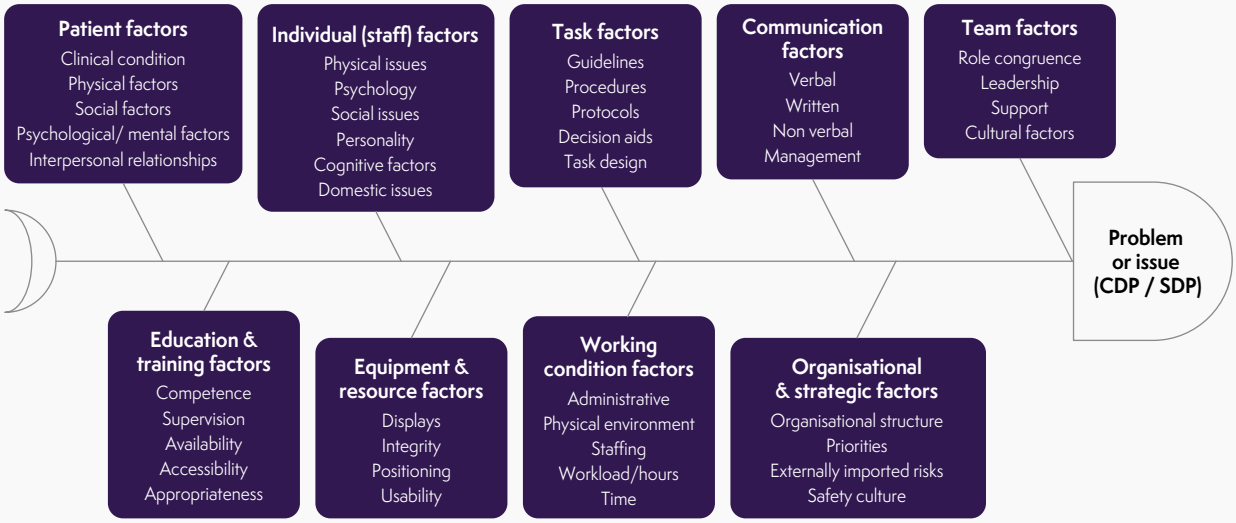

Figure A8.1: Fishbone cause and effect diagram (reproduced from Fereday S. A Guide to Quality Improvement Methods. HQIP; 2015)[7].

Group ideas around themes which can be created by the group or based on the following generic categories:

- patient factors
- individual (staff) factors
- task factors
- communication factors
- team factors
- education and training factors
- equipment and resource factors
- working condition factors
- organisational and strategic factors.

For each category, the team should consider 'Why does/did this happen?' and then go deeper and deeper by asking why at least five times, a technique known as the 'five whys'.[11] As a quality improvement example, consider how you would use this diagram to prompt brainstorming about the reasons why first cases in the operating theatre don't start on time in your organisation. Further reading and practical information is provided in the references below.

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A9 How do you know a change is an improvement? Using run charts

Dr Malcolm Daniel, Glasgow Royal Infirmary
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Data collection is part of all improvement work. Collected data have traditionally been 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 run charts; 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 overreact to the data and apply subjective rules to affirm whether a 'shift' has occurred or whether a 'trend' is present. There are specific

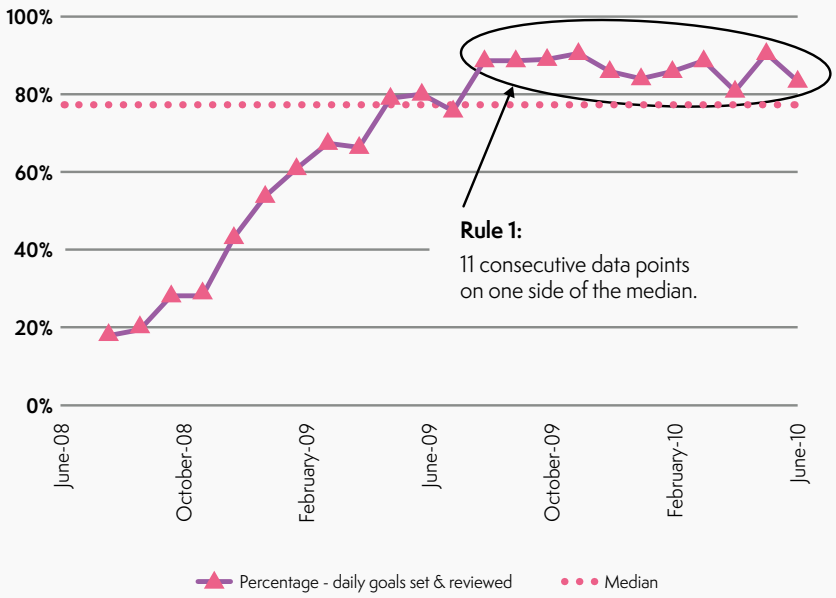

Figure A9.1: Run chart showing that a shift has occurred; that is, when six or more data points lie on the same side of the median.

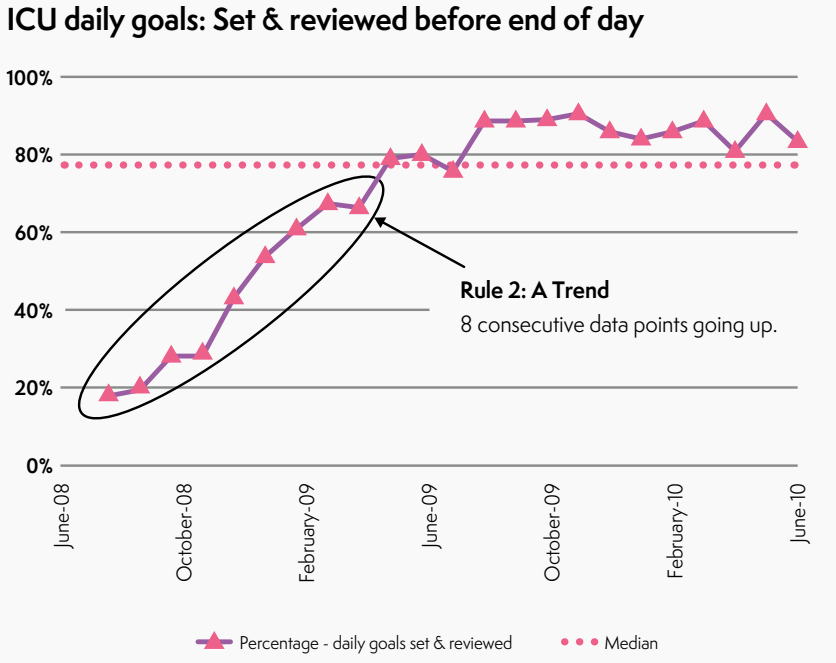

Figure A9.2: Run chart showing a trend. There are five consecutive data points (or more in this case) increasing in sequence.

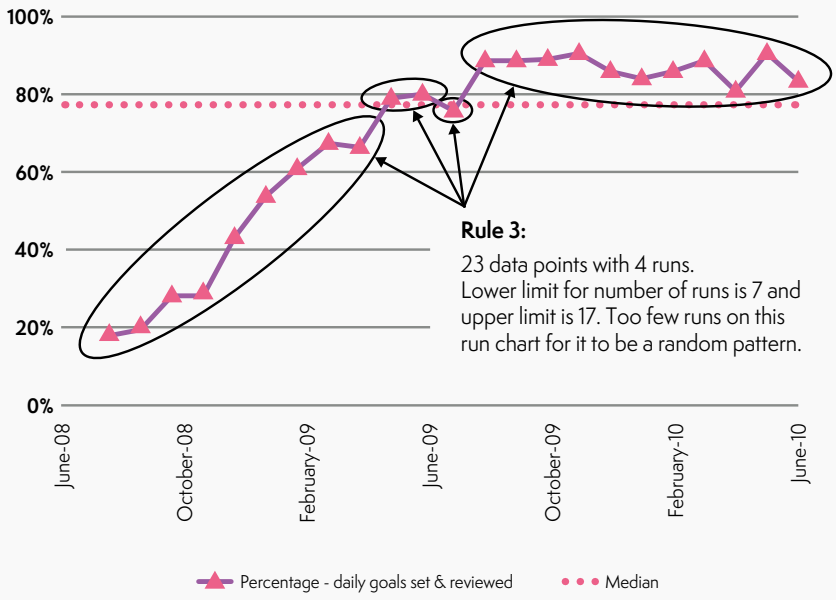

Figure A9.3: Time series data (or a run chart) showing a number of runs.

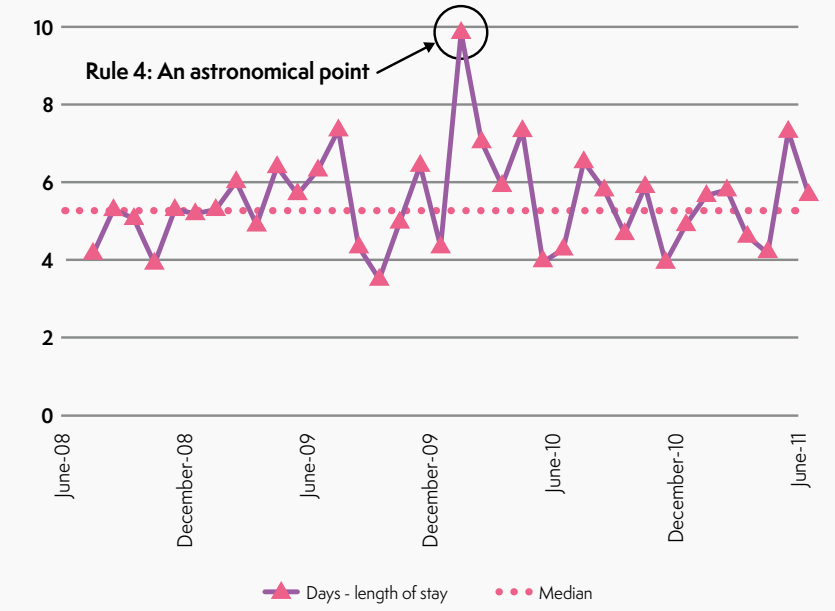

Figure A9.4: Run chart with an astronomical point.

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.

Rule 1: A shift

A shift has occurred when six or more data points lie on the same side of the median (Figure A9.1). This can be either above or below the median. When counting data points, some may lie on the median. These data points do not contribute to a run; ignore them and continue counting.

Rule 2: A trend

A trend has occurred when there are five consecutive data points either increasing or decreasing in sequence (Figure A9.2). 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.

Rule 3: Number of runs

A run is a series of data points on one side of the median. A data or point or points that lie on the median do not interrupt a run. The number of runs can be simply calculated be counting the number of times the line connecting those data points crosses the median and 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 A9.3). A table exists that compares the number of data points and the expected range of how often the median should

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be crossed.[2] This allows us to determine whether there are too few or too many runs.

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 A9.4). When an astronomical point is seen, you should question what else was going on at the time, as this is not normal variation. For example, a run chart of hospital mortality during a severe flu epidemic could have an astronomical point.

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, which 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. First, a run chart displays measures over time and makes progress visible to those on the team. Second, 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 whether 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. Third, the run chart has time series data. These data are particularly useful in helping to determine whether 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 whether 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 programme. For almost all hospital improvement 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.[3–5] The simplicity, together with the probability based run chart rules, provides an easy yet powerful method for assessing the impact of the changes we have made. This provides an objective method to determine whether the changes we have made to the process have led to 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 A9.5).

Acute Pain in Elective Orthopaedics: Primary hip & knee replacement
Process AIM: Bundle reliability > 95% by end of Jan 2010
Outcome AIM: Reduce incidence of even one episode of severe pain by 50%

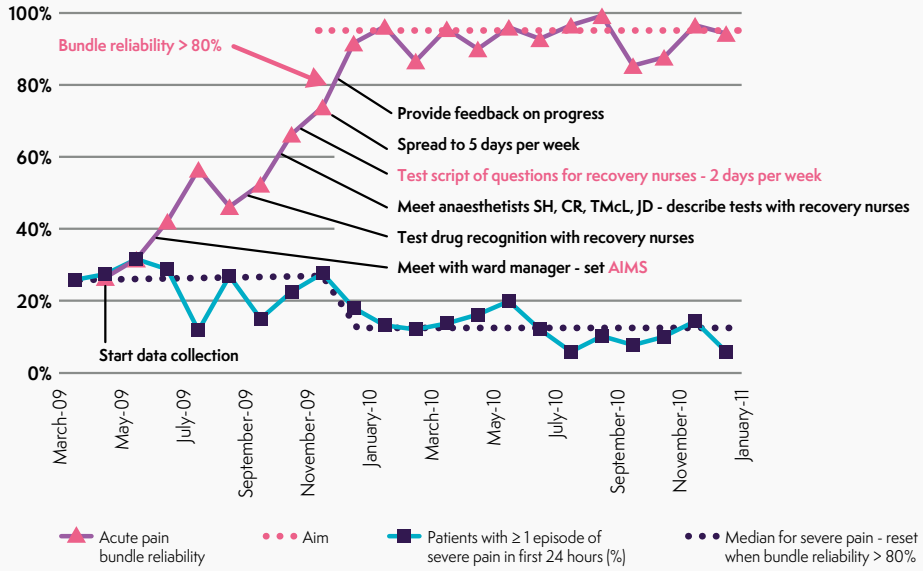

Figure A9.5: Run chart showing both outcome and the process being improved on the same chart. Annotation also helps the reader to understand what effect changes have had.

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A10 Statistical process control charts

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Statistical process control (SPC) charts (or Shewhart charts, after their developer Walter Shewhart), are used to identify and understand variation in a system.

When a biological variable is repeatedly measured, such as a daily blood pressure reading, variation occurs over a period of time This effect is called 'common cause variation'. However, when an intervention occurs (eg a patient forgets to take their antihypertensive medication, or the drugs used to treat their hypertension are altered) then 'special cause variation' will have taken place.

The distinction between 'common cause variation' and 'special cause variation' is important. Common cause variation is inherent in the system and is therefore predictable. To change common cause variation or improve the system, system redesign is needed. Special cause variation requires either investigation of the cause of the variation, or it may provide evidence that changes made to the system are having an effect.

Section A9 of this book discusses run charts. A run chart and an SPC chart have a number of important differences. A run chart can be constructed with fewer data points than an SPC chart and is more than adequate for most improvement projects. However, a run chart does not have the more rigorous statistical approach that SPC charts have and does not show upper and lower confidence limits, which are calculated in relation to the data being plotted. SPC charts are used to provide a greater degree of confidence that the system is stable (ie no points are falling outside of the confidence limits) or that change is really happening (ie data fall outside the confidence limits). SPC charts are more likely to be used when publishing work from a quality improvement project. A major advantage of SPC analysis over more familiar statistical analysis is that SPC charts take into account continuing change over time, rather than aggregating data from two static time points such as 'before' and 'after'.[1,2]

SPC charts have a number of key elements:

- Data points are arranged over time in time sequence.
- The centre line is the calculated mean or median.
- Statistically calculated upper and lower three sigma limits. These are called the 'upper' and 'lower' control limits.
- Between the upper and lower control limits and the central line, two further lines can be shown representing 1 and 2 standard deviations from the central line.
- There are a number of different types of SPC charts such as a P chart for binomial data (eg pass or fail). The type of chart needs to be selected appropriately for the type of data.

To make an SPC chart, it is usual to have 25 or more consecutive points of measurement. Many software programs are available to assist in the construction. However, the first step is to decide which SPC chart is appropriate for the data set and whether the data are continuous or discrete. Flow charts are available to assist in the decision-making process.[1–3]

Once the chart has been chosen and constructed, the question then arises as to whether common cause or special cause variation exists. Any one measurement outside the upper or lower control limit is accepted as a special cause variation and should be investigated. When sequential data points lie between the upper and lower control limits there are further rules for determining whether special cause variation has occurred).[1,2]

As with run charts, SPC charts are particularly helpful when attempting to change a process or pathway. Once a stable baseline has been confirmed with only common cause variation, then attempts to change the pathway can be plotted over time and indicated on the graph. It is especially useful to see how different interventions such as education, meetings or new ways of working can impact on the overall outcome desired.

Are SPC charts inferior to standard research methodology?

Many randomised controlled trials try to exclude the effect of normal variation by collecting large sets of data over prolonged periods. The variable under study is aggregated into a larger group and then compared with another group. The trouble with this type of study is that it may take many months or years to establish the effects of an intervention. SPC charts provide statistical rigour and, by using time sequence charts to study change over time, are able to detect changes at an earlier time than randomised control studies, and to observe whether normal or common cause variation is making a difference[3]. SPC charts actually help us to understand

what happened in our research, not just whether change happened or not. For example, the Emergency Laparotomy Collaborative used SPC charts.[4] The charts showed us that although there was an improvement in processes through implementation of a care bundle, some changes did not occur until the second year of the study.

SPC charts are gaining significant popularity among medical researchers, who find the graphical representation of change and early signals of performance change (often related to specific interventions) very helpful.

Finally, there are many types of SPC chart, as identified above, which can use data from a variety of different types of distributions such as Poisson, binomial or geometric. In addition, charts are available to study rare events such as 'never events' or the acquisition of methicillin-resistant Staphylococcus aureus bacteraemia or mortality. Further references are provided to help readers interested in these areas.[1–5]

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A11 Performance polygons for representing multidimensional data

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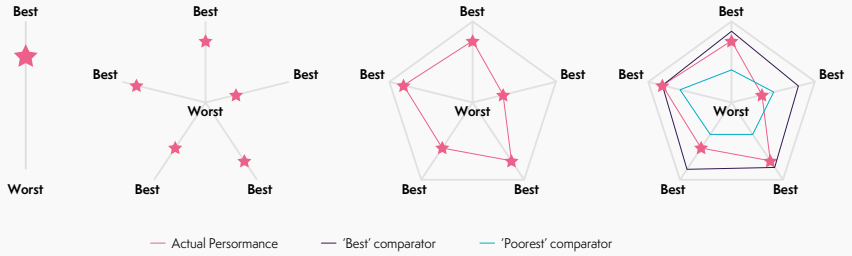

Figure A11.1: Construction of a performance polygon.

Measurement of healthcare outcome is central to assessing quality and quality improvement. Although healthcare performance has often been presented in a single dimension (eg a 'postoperative pain audit') healthcare quality is complex and often involves several related or conflicting outcomes with importance depending on your particular focus; for example for tonsillectomy, the patient's focus (pain and nausea, readmission rate, time off school or work), the anaesthetist's (nausea, pain, daycase rate), the surgeon's (operative time, bleeding, readmission rate), the theatre manager's (theatre time, cost) and the hospital management's (cost, daycase rate), and all outcomes differ.

Relying on single outcome measures encourages 'silo mentality'. Changes in practice intended to improve one outcome (eg pain on waking) may adversely impact others (eg postoperative nausea and vomiting, time in recovery). During practice change, measuring 'balancing measures' may enable unintended consequences to be captured. Performance polygons are a form of data representation, reflecting the complexity of outcome measures. Examples are shown but are not intended to define which outcome measures should be used when measuring perioperative (or other) quality. Performance polygons provide an easily assimilated visual indication of multiple quality measures in one graph.

Performance polygons qualitatively represent multidimensional data, making understanding of overall performance easier. They are derived from star charts.

A performance polygon is constructed as follows (Figure A11.1):

- An outcome measure is plotted on a single line, with better performance indicated by a longer line.
- Additional measures are added as equally spread 'spokes' spreading outwards from same origin (four measures 90 degrees, five measures 72 degrees etc).
- Performance data is plotted and the points are joined, forming a 'performance polygon'.
- Comparator polygons are superimposed as benchmarks, with the reference measure (often the 'optimum outcome') in each domain represented by the same length line, to create an equilateral polygon.

Comparator polygons can be internal (eg temporal changes in an individual's multidimensional performance) or external (eg predefined benchmarks) and may be used to represent the performance of individuals or groups.

Example 1 comparison with departmental performance

Figure A11.2 shows an individual anaesthetist's performance with exemplar outcome measures in recovery. Chosen outcomes are of interest to patients, surgeons, recovery staff, managers and anaesthetists and include measures of anaesthetic skill (regional block

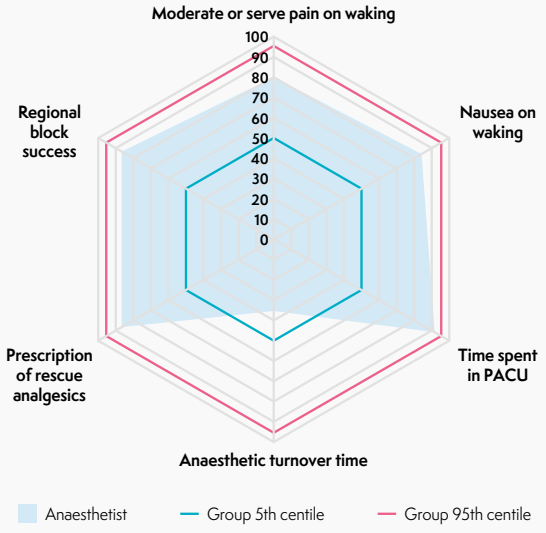

Figure A11.2: Comparison with departmental performance.

success), process variables (good prescription practice), efficiency measures ('turnaround' time) and patient-relevant outcomes (pain, postoperative nausea and vomiting): all measures of anaesthetic performance.

This anaesthetist achieves above average/very good outcomes compared with the reference group but is slow. Criticism about slow service may be deflected by the high-quality patient-centred outcomes. The anaesthetist might focus on improving speed while maintaining outcomes.

Example 2 performance polygon: surgical team performance

Figure A11.3 shows multidisciplinary multidimensional outcomes after knee arthroplasty. All outcome measures are of interest to all team members but individuals may influence some outcomes more than others: the anaesthetist (theatre time, time to mobilise and EuroQoL Quality of Life, EQ-5D, score), surgeon (theatre time, complication rate and Oxford knee score), nursing and physiotherapy care (time to mobilise, EQ-5D score and length of stay). Managers will focus on time in theatre and length of stay. Most importantly, the patient will probably be most interested in EQ-5D score, length of stay and Oxford knee score. Other outcomes of interest could be added or substituted to create a polygon with a different focus. The quality of performance is high, with excellent three-month outcome: the team might address those measures that are closest to the median and turn length of stay from good to excellent.

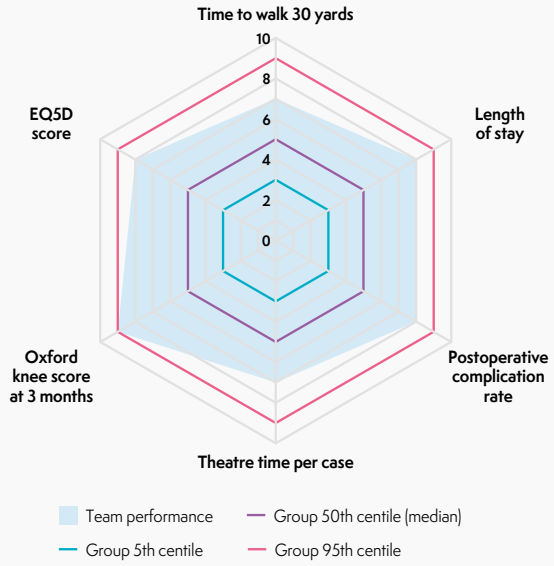

Figure A11.3: Performance polygon: surgical team performance for total knee arthroplasty. The EQ-5D measures global wellbeing in five health-related domains. The comparator polygons are the 95th and 5th centiles and median performance of a reference group, which might be historical data, performance in the neighbouring theatre or trust, or nationally acquired data.

A performance polygon such as this might be used to compare surgical or anaesthesia practices. For instance, during debate about the best surgical or anaesthetic/analgesic method to use for knee arthroplasty, a performance polygon might provide a better balanced assessment of the utility of different techniques than the traditional approach of a pain audit. A performance polygon could compare performance after introduction of an enhanced recovery after surgery programme, illustrating not only on length of stay but also on balancing measures such as pain on discharge and readmission rates.

Comment

Performance polygons have a multitude of potential designs and uses in any specialty. As they provide multidimensional information, they may be especially valuable when balanced measures need to be considered (eg in preparing for training assessment or appraisal or responding to a complaint). Using a large database, 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 to identify individual lower outliers (so they may learn from others). They also usefully represent change such as the introduction of new techniques or procedures or, in research, to show both primary and secondary outcomes. As with many quality measures, large complete datasets and sequential data are likely to be of greatest value.

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 importance even if represented with the same 'weight'. Quantitative analysis of performance polygons is likely to be difficult, but the use of z-statistics is one option to develop the tool further.

A11 Performance polygons for representing multidimensional data

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Conclusion

Performance polygons are a simple, powerful way to represent data over several domains. Their visual representation is easily understood. Adding comparator polygons enhances their value and can transform the polygons from simple graphical displays to a potential driver of change and quality improvement.

Further reading

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Quality improvement in anaesthesia

A12 Checklists

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Checklists are ubiquitous in our daily lives and in our healthcare practice. Many of the recipes in this book may propose a checklist or bundle to ensure better compliance with best practice standards. Checklists are often introduced in an effort to reduce complexity and to prompt users 'just in time' to consider certain steps or perform certain actions. Complexity is part of modern clinical practice and checklists have been shown to improve outcomes in clinical care and are standard 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] More recently, studies done on the implementation of checklists in healthcare have indicated why some checklists work well and others do not.[3]

A good checklist should:

- Be evidence-based, trialled and tested before introduction, perhaps using simulation.
- Be focused to deal with a particular set of issues or tasks.
- Only contain five to nine items in each section.
- Prompt communication and confirmation of information.
- Be easily accessible when needed and clearly designed, using familiar language.

The World Health Organization (WHO) surgical safety checklist and other surgical checklists have been found to improve surgical morbidity and mortality in a range of settings,[4] but the impact of the WHO checklist is crucially dependent on compliance and the local context.[5,6] The introduction of a checklist to improve central line infections improved safety but these programmes were not solely based on the introduction of a checklist.[7,8] They were accompanied by a rigorous measurement schedule, a training scheme for all staff involved, senior executive support and project coaching. Design and implementation of a checklist is a complex process.

Consider the type of problem

- Consider the type of problem you wish the checklist to address. Some issues are simple, technical issues, such as checking the patient's identity or whether essential imaging is displayed in the operating theatre. These are suitable topics for a simple checklist.
- Complex or socio-adaptive problems require discussion and teamwork, and the answer may change depending on the circumstance (eg discussing critical or unusual steps in an operation or the 'plan B' in a difficult intubation in the emergency department). These are rarely fixed by implementation of a simple checklist, but require improved teamwork, communication, training and other elements as part of the package.[9,10]

Consider your local context

- Variable performance may be improved by a checklist, but it is also likely to be due to different attitudes among members of staff and different environments. We all know theatre teams who perform the WHO checklist well and those who do not, even within one hospital. This kind of variable performance could be better addressed with team training and understanding why performance is different, and perhaps addressing individual performance.[6,9,10]

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A13 From audit to action: the power of trainee networks

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Completing an audit is only the beginning

The Healthcare Quality Improvement Partnership defines clinical audit as 'a quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit measures and the implementation of change'.[1] While it can be relatively simple to perform an initial audit, taking the next step and improving the quality of care is much harder.

Identifying the area for improvement

The first step is to identify 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 this compendium, National Institute for Health and Care Excellence (NICE) guidance, royal college or professional society guidelines, findings of National Audit Projects (NAP) of the RCoA or NCEPOD reports. As an example, the use of capnography for out-of-theatre intubation was recommended in NAP4 and was endorsed by statements from the Association of Anaesthetists and the Intensive Care Society.[2] Today, capnography is widely accepted as standard practice for any intubation. This was not always the case and implementation was helped in part by audit and quality improvement.

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. In our example, there was strong evidence that using an intubation bundle including capnography reduced the rate of adverse events associated with intubation in the intensive care unit.[3]

Identifying current practice

The next step is an audit of current practice. This key step can highlight any deviations from best practice and can motivate people to change. The majority of audits will be local departmental projects. Coordinating a regional audit became much easier, however, with the emergence of trainee research networks. These networks now cover the vast majority of the UK, with increasing membership and project participation. Many are supported by their local school of anaesthesia and have a resilient governance structure, consultant supervision and nominated trainees in each hospital to lead projects. Since December 2013, they have been overseen and coordinated by an umbrella organisation called the Research and Audit Federation of Trainees, allowing the facilitation of national projects.[4] Anaesthesia and critical care trainee research networks have now delivered many high-impact regional audits of practice, which have been published. Subjects include perioperative diabetes management, ventilation on intensive care units, blood transfusion and central line complications.[5–8]

Whatever the scale of the audit, it is vital to ensure that within each hospital the appropriate audit registration procedures are followed and that each department is aware of the process from the outset. In our example, a prospective audit of out-of-theatre tracheal intubation practice around the West of England region identified wide variation in the use of capnography between sites, and also identified other areas for potential quality improvement. The project was run by one of the first anaesthesia and critical care trainee research networks (Regional Trainees in Intensive Care Severn, RTIC). The nominated trainee at each site was responsible for optimising data capture and quality, although the methods they used were left up to them.[9]

An intervention to improve practice

In general, simply exhorting people to 'do better' is not effective at improving quality. It is more effective to introduce processes with the quality interventions you seek to introduce built in. The development of standardised processes empowers all members of the multidisciplinary team to demand standards of care that they might not otherwise feel they could ask for individually. In the RTIC project, the intubation checklist was written to standardise out-of-theatre tracheal intubation practice 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 in which it will be used. If staff cannot understand the rationale for new processes, they may feel that changes are being imposed on them for no reason. Using plan–do–study–act (PDSA) cycles allows users to design the process to make their life easier, while retaining the 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. The RTIC 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 to present a robust business case for investment.

As part of the RTIC project, audit data were presented at both local and regional level and were subsequently published.[9] Trainees from all hospitals in the West of England region were involved in developing the checklist, which was widely used within this region prior to being featured as an appendix to the NAP4 report.[2]

It has now been disseminated internationally, mostly via social media, with adaptations of the original RTIC checklist being used in hospitals from as far afield as the United States and Australia.[10]

Documenting your success

The process of quality improvement is continuing, and it is important to audit practice repeatedly to ensure compliance. The audit should have been registered with the hospital and they will keep a record of it. Where specific quality indicators have been identified, improvements should be documented to encourage continued engagement. Finally, you should to continue to survey practice over time to ensure that standards do not slip and to demonstrate the effectiveness of your intervention.

Acknowledgements

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A14 Co-design and working with patients

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There are many ways that we can include patients' perspectives in improvement work, including surveys, focus groups, listening events, observations, shadowing and more.

'Co-design' refers to staff and patients working in partnership to improve services so that both staff and patients contribute to the design of new improvements.[1] This can be moved one stage further, with 'co-production' referring to staff and patients working together not only to design changes but also to implement them (eg patients writing new information leaflets).[2] Remember that patients may bring unique skills from their own backgrounds and training to help your improvement work.

Co-design is often used when trying to improve the patient's experience of care. This is the basis for experience-based co-design, which has been developed by the Point of Care Foundation charity. The Point of Care Foundation has developed a toolkit available to support those wanting to work more with patients.[3]

Working with patients as active partners in improvement is certainly trickier to set up than working with staff, but has many potential benefits, not least of which is ensuring that whatever changes are made are most likely to work well for patients.

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Quality improvement in anaesthesia

A15 Changing behaviour

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Most quality improvement work involves trying to change behaviour, usually clinical behaviour; for example, to get staff to comply with existing guidelines or to start following new guidelines. We may approach behaviour change by disseminating the new practice in an updated guideline or perhaps by raising awareness in a teaching session, department meeting or posters and emails. However, these approaches often do not lead to widespread adoption of new practices. We also have to think about what motivates people to change and what are the barriers that stop them from making change. Psychologists use a variety of frameworks and approaches to describe behaviour change and the barriers to changing behaviour. Some of these have been used successfully in healthcare to aid implementation of new guidelines, such as the York and Humber achieving behaviour change patient safety toolkit, the COM-B model (capability, opportunity, motivation) and behaviour change wheel, and the Institute for Healthcare Improvement's psychology of change framework.[1–3]

For example, a team looking at intraoperative handover wanted to ensure that anaesthetists followed a checklist when handing over during a case. They presented the new checklist at the departmental meeting and wrote a policy but found that many people were still not following the new process. Using the York and Humber achieving behaviour change tool, they surveyed anaesthetists asking why they did not hand over according to the policy. The answers revealed that some staff thought it took too long, some intended to do it but often forgot, and some did not think it was important to use the checklist. This gave the improvement team several areas to work on: they streamlined the checklist, they placed the handover checklist in a prominent place on the anaesthetic machine, and they shared some examples of critical incidents involving forgotten information at handover, to highlight the importance of the task. These steps improved compliance with the new guidance more than an education session alone.

Time would have been saved in the example above if the critical incidents problems had been shared initially. Provide clinicians with data to illustrate what the problem is at the beginning of the project. If data are combined with patient stories about what impact the change may have on their patients, then the impact is increased. Think about the lessons from emergency laparotomy. Understanding that the mortality for your hospital is 10% at 30 days is made much more impactful when you hear what that number means to a family that lost a loved one. For other projects, one team member may be motivated by wanting to change a process that is slow and cumbersome and another team member may be interested in getting some improvement work on their CV. There are some relatively easy reads available that discuss some theories on motivation and can help you to think how you use change management theories in your improvement work.[4,5]

Remember that we all respond well to feedback, celebration of success and being part of a team. Engagement is increased by making meetings short, effective and including food! Give teams regular feedback about what is working and what is not. Celebrate success and publicise success in any way possible to keep momentum going. Leading change is hard, so you need to be resilient and build your networks of volunteers and champions, who will work with you to make change happen.

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Quality improvement in anaesthesia

A16 Habits of an improver

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Most of this book takes the perspective of helping you and your team with practical guidance on how to structure your measurements and use the correct improvement tools. We know that this is only part of what is needed to make improvements, and that training in improvement methodology alone does not result in staff feeling confident and capable to do quality improvement work.

Professor Bill Lucas and Hadjer Nacer from the Health Foundation have proposed a different way at looking at the field of improvement, describing the key 'habits' seen in people undertaking improvement. These habits are complementary to skills or knowledge, and the proposed 'habits' are being used to develop quality improvement teaching and the curriculum to ensure that we are not just knowledgeable, but that we can use learned improvement skills in the real-world environment.

The diagram in Figure A16.1 lists the habits in five categories: learning, influencing, resilience, creativity and systems thinking. Central to all these habits is good communication, and more central again is co-producing health and social care with patients.

There is a fuller description of each of the habits in the full document.[1]

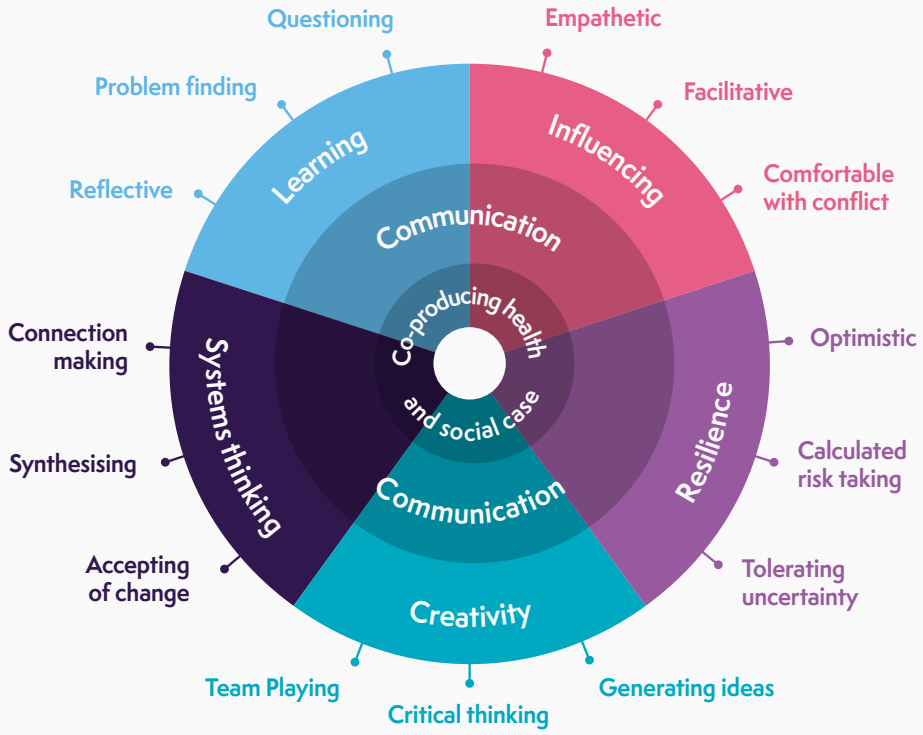

Figure A16.1: The habits of an improver.

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Quality improvement in anaesthesia

A17 Spread and sustainability: how to spread effective ideas and plan for sustained improvement

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This book is all about undertaking improvement work. However, achieving a short-term improvement that fades over time is not an effective use of resources. In addition, if you have a successful improvement project which achieves positive change for your patients, you may want to spread it to further areas of your hospital or to other organisations. There are well-recognised pitfalls of spreading change too early, before your improvement work is ready, which may destine the project to fail. Equally important is maintaining change after the first flush of success. During planning of any improvement project, thought should be given to how successful change can be sustained; for example, what happens when junior doctors rotate or when team leaders leave? Fortunately, there are a number of resources to signpost important considerations for both spread and sustainability.[1–4]

Spread can be defined as actively disseminating best practice and knowledge and implementing each intervention in every available care setting.[1] The Institute of Healthcare Improvement has described the 'seven spreadly sins', which if indulged are likely to lead to failure of the improvement when it is spread.[2] The sins are:

1. Don't bother testing just start with a large pilot.
2. Give one person the responsibility to do it all and depend on local heroes.
3. Rely solely on vigilance and hard work.
4. Spread the success unchanged – don't waste time adapting for different contexts.
5. Require the person or team who drove the initial improvement to be responsible for much wider spread.
6. Check huge amounts of monitoring data at infrequent intervals.
7. Expect huge improvements initially and start spreading right away.

Sustainability can be defined as ensuring gains are maintained beyond the life of the project.[1] The NHS Institute developed a sustainability model which consists of 10 factors encompassing process, staff and organisational issues.[3] Factors that are likely to help to sustain a project which should be considered when planning for sustainability include:

- Does the project have benefits beyond directly helping patients (eg does it reduce waste or cost)?
- Are the befits of the project credible? For example, do all staff know about it and believe in the benefits?
- How adaptable is the new process? Can it be altered for different contexts? Does it depend on specific individuals?
- How will the new process be monitored? Is there a feedback system? Are mechanisms in place to monitor beyond the end of the project?
- How will staff be trained to sustain the process?
- Can frontline staff feed back and change the process as necessary?
- Is there senior leadership support and are the leaders taking personal responsibility to help to break down barriers?
- Are the clinical leaders trusted, influential and believable? Are they actively involved?
- Do the changes fit with the organisation's strategic aims and culture?
- Are there enough resources to support the new process?

These are many things to consider, but without time, financial and leadership support and a culture that is ready for change, improvement is very difficult.[4] Improvement work is particularly vulnerable if it seen to be owned by an individual or a small group, and if it is perceived as a short-term project.[5]

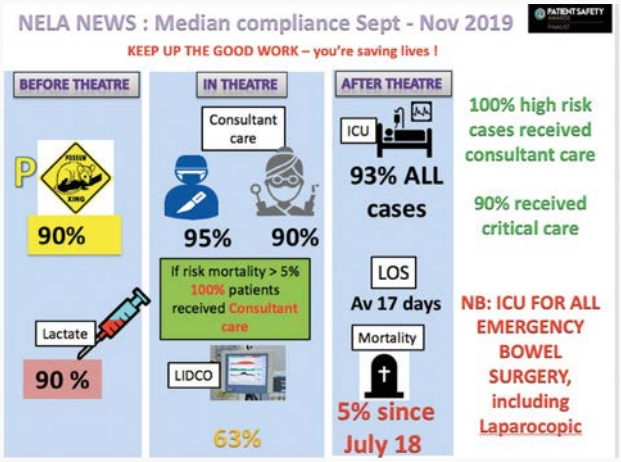

Figure A17.1: A communication newsletter designed to keep all staff engaged in sustaining the emergency laparotomy work at the Royal United Hospital, Bath.

Communication is absolutely essential to a successful sustained project.[6,7] Taking into account the spread and sustainability issues highlighted above, the more people who are involved in a project, who feel part of it and or know what has been achieved, the more likely the project will become embedded as 'the way we do things around here'. Figure A17.1 shows an example of a communication newsletter designed to keep all staff engaged in sustaining the emergency laparotomy work at the Royal United Hospital, Bath.

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A18 Publishing your quality improvement work

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The definition of audit includes an evaluation of a specific quality or quantity. 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 its heart is the requirement for people, including the people leading the work, to change how they do part of their work. This makes it different from research that examines whether one drug or intervention is better than another in some dimension. 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 almost always involves more than one change, and subsequent changes are based on learning gained as the work progresses, also termed 'iterative change'. This difference has often led to difficulties in getting improvement work published, often as it does not fit the traditional introduction, methods, results and discussion structure used in medical journals.

The Standards for QUality Improvement Reporting Excellence (SQUIRE) guidelines were first published in 2008 with the aim of increasing both the quantity of improvement work published and the quality of the published work.[1] These guidelines function in the same way as the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomised controlled trials and, similarly to the revisions to CONSORT over time, SQUIRE was reviewed, updated and published as SQUIRE 2.0 in 2016.[2] The SQUIRE guidelines provide a checklist that helps anyone working on an improvement project to design and frame their work. It is based around four fundamental questions: 'Why did you start?' 'What did you do?' 'What did you find?' and 'What does it mean?'

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 to 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. Importantly, include a description of the rationale for the work. This would cover both what you thought were the reasons for the problems that existed in the process, and how the changes initially proposed would lead to improvement.

What did you do?

When we do quality improvement work, we intend to make changes to what is or was routine care. Therefore, describe what was done and how these changes were implemented. Changing routine work will be dependent on the characteristics of the setting or context in which it occurs. SQUIRE 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. It is common in improvement work to find that the initial proposed changes do not work and this leads to further changes based on the learning.

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 a result, the improvement strategy may change from learning obtained as the data are gathered over time. It is important to record and share these changes. Annotating the run charts to provide a timeline of what changes were made will provide your readers 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.

What does it mean?

There is a difference between 'doing' improvement and 'studying' improvement.[2] The 'doing' element focuses on what happened to the process and outcomes as part of the improvement work. When 'studying' improvement we should consider whether our rationale for the improvement holds or needs to be updated based on our experience and learning. It also considers the wider impact on the local setting of the improvement work.

SQUIRE 2.0 provides an excellent resource for designing and writing up an improvement study. Helpfully the guideline website (**www.squire-statement.org**) includes an 'explanation and elaboration' section which provides some worked examples. More journals now publish improvement work. BMJ Open Quality was developed just to publish peer-reviewed healthcare work and the improvement reports are listed on PubMed. The website also provides resources such as templates to help run and write up improvement work.[3] The contents of this RCoA document, together with 10 valuable tips provided by an experienced improver, will help you to make improvement part of your daily work and will help to communicate your learning to others.[4]

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