British Association of Perinatal Medicine

in collaboration with NNAP National Neonatal Audit Programme

Improving Normothermia in Very Preterm Infants

A Quality Improvement Toolkit

September 2019

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Introduction

The British Association of Perinatal Medicine (BAPM) aims to improve standards of perinatal care by supporting all those involved in providing this care to optimise their skills and knowledge. A key value of the BAPM is 'working collaboratively' to provide the safest and most effective service for babies and families and our current strategic aims are to deliver high quality perinatal care and provide support for perinatal professionals.

The National Neonatal Audit Programme (NNAP) is commissioned by the Healthcare Quality Improvement Partnership (HQIP), delivered by the Royal College of Paediatrics and Child Health (RCPCH), and funded by NHS England, the Scottish and Welsh Governments. The NNAP assesses whether babies admitted to neonatal units in the United Kingdom receive consistent high-quality care. It sets evidence-based standards on key clinical outcomes and in turn identifies areas for quality improvement (QI) in relation to the delivery and outcomes of neonatal care.

With these shared goals in mind, the BAPM and the NNAP are collaborating in a national quality improvement initiative which will target key NNAP measures and will align with and support other neonatal national workstreams such as the Maternal and Neonatal Health Safety Collaborative (MNHSC) in England and the Maternity and Children Quality Improvement Collaborative, Scottish Patient Safety Programme (MCQIC-SPSP) in Scotland, while avoiding duplication. Each improvement drive includes a QI toolkit mapped to the BAPM Neonatal Services Quality Indicators (NSQI), (Appendix 3) and has been developed by clinicians who have shown excellence in the area of focus, led by the multidisciplinary BAPM Quality Group. Improvement at local and national level as a result of improvement work undertaken will be measured by the NNAP.

Each toolkit will:

a. Provide the evidence base for effective interventions
b. Facilitate units in interrogating their own data and processes in order to undertake selected quality improvement activities suited to the local context
c. Assist units in interpreting and monitoring the results of their QI activities
d. Provide and signpost resources to facilitate QI in the area of focus.

The toolkit has been designed using well-established QI methodology and in accordance with the Royal College of Paediatrics and Child Health 'Quality Improvement in Child Health' Strategic Framework[1]. The toolkit will introduce some basic QI tools and methods that are quick to learn and easy to apply. In addition the BAPM website also offers a range of free QI resources, links to easy to use templates and e-learning, QI tutorials and a forum for shared learning (www.bapm.org/quality). The toolkit is not intended to replicate any existing local or national QI activity undertaken in the area of focus but to complement these endeavours with a practical step by step guide.

Background

The World Health Organisation (WHO) defines infant hypothermia as a core body temperature of <36.5°C, or a skin temperature of <36.0°C[2]. Preterm babies are at particular risk of hypothermia with

associated adverse effects including an increased risk of hypoglycaemia, hypoxia and metabolic acidosis, respiratory distress and chronic lung disease, necrotising enterocolitis, intraventricular haemorrhage, late-onset sepsis and death[3]. In 2015, the International Liaison Committee on Resuscitation (ILCOR) concluded that admission temperature of newly born non-asphyxiated infants was a strong predictor of mortality and morbidity at all gestations and published a consensus statement that temperature should be maintained between 36.5°C and 37.5°C after birth through stabilisation and admission[4]. Emerging data also suggests an association between admission hyperthermia (>38°C) and adverse outcome and highlights the need for continuous temperature monitoring during stabilisation[5]. It should be noted that the normal fetal temperature is above 37.5°C and may increase in labour even in the absence of chorioamnionitis, and therefore a mild elevation of temperature which is seen in some infants at delivery may not be wholly modifiable[6].

Since 2006 the NNAP has collected information about the admission temperature of preterm infants, and from 2015 has asked "*Does an admitted baby born at less than 32 weeks gestational age have a first measured temperature of 36.5°C to 37.5°C within one hour of birth?*"

The NNAP sets a standard that the composite measure of timeliness and normal temperature should be met for at least 90% of babies. In 2017 the national rate of compliance was 64.4%, with a range of 30%-96% in units with more than 20 eligible babies. Over 20% of babies in 2017 were hypothermic on admission. There has been an improvement of only 12% since 2013, and one third of units have shown no improvement or a decline in performance between 2015-2017, (NSQI 12)[7]. Consequently, implementation of evidenced-based thermal care strategies is required to address this issue.

The NNAP normothermia measure is one of seven interventions within a Preterm Perinatal Wellbeing Package developed by the MCQIC-SPSP in Scotland to improve preterm outcomes[8]; and in England within the MNHSC, hypothermia is an improvement focus in the optimisation of very preterm infants[9]. Other standards and initiatives relating to normothermia are listed in Appendix 2 (NSQI 11).

Evidence

There are a wide range of strategies to minimise heat loss and promote normothermia. Some of these have a foundation of high-quality evidence while others are considered best practice and are derived from observational work and consensus expert opinion. An understanding of the mechanisms of heat loss gives insight into areas for intervention. A full review of all evidence is outside the scope of this toolkit but a summary of the highest quality evidence and consensus opinion can be found below in Table 1 (NSQI 1, NSQI 11).

There are a large number of quality improvement studies in the literature which report improvements in normothermia with the co-application of various other interventions in specific settings. These include continuous temperature monitoring, repeated recording of temperature during stabilisation, thermoregulation role allocation during stabilisation, active heat on transportation, delivery room checklists, formalised communication, targeted education and simulation training[10-16]. While not evidenced within trial settings, clinicians may wish to test such low risk interventions, bearing in mind how differences in local context may modify success.

How to use this toolkit

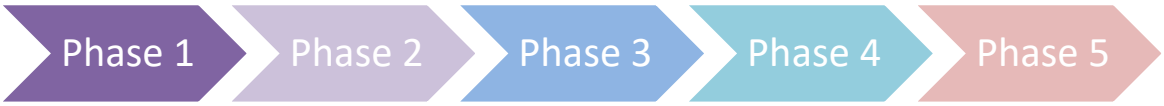
This toolkit is not intended to be read as a guideline which mandates a standard practice for all units. Instead it is a practical resource from which units, who wish to improve their normothermia rate, can select the most suitable interventions for their own particular context. For example there are some units who achieve high compliance with normothermia and who do not use occlusive wraps or bags, and many others who perform highly without the use of humidified gases or transwarmer mattresses. Individual units are encouraged to interrogate their own processes in order to understand where and how infants become cold in their local setting and select interventions which are best suited to their needs. It should be noted however that evidence exists showing that initiatives which address several methods of heat loss in the newborn are more effective than those that a single method alone[17-19].

Table 1. Interventions to reduce heat loss

	Mechanism of heat loss	Intervention	Evidence or Professional Recommendation
Evaporation	Loss of moisture and heat from warm wet skin into a low humidity, cooler environment Loss of moisture and heat from respiratory tract mucosa	Occlusive plastic wrap/bag Woollen or plastic hat Warm, humidified gases	A 2018 Cochrane Review concluded that plastic wraps improved core body temperature on admission to NICU and that fewer infants had hypothermia on admission to NICU or up to 2 hours after birth with a number needed to treat for an additional beneficial outcome of 4[3]. Two multicentre, randomised controlled trials have shown significant reductions in admission hypothermia in preterm infants resuscitated using warm, humidified inspired gases above standard care (wrap, woollen hat and radiant heat) [20,21].
Convection	Heat loss due to cooler circulating air, particularly in the context of open windows and doors	Increased room temperature	The American Heart Association (AHA) [22], European Resuscitation Council (ERC) [23], UK Resuscitation Council[24], World Health Organisation (WHO) [1] and International Liaison Committee for Resuscitation (ILCOR)[4] all recommend increased room temperature for anticipated preterm deliveries <32 weeks. The recommended temperature varies from 23-26°C. There are multiple studies demonstrating the benefit of increased room temperature on body temperature at 5 mins from birth and admission temperature [25-30].
Conduction	Heat loss due to direct contact with cooler surfaces	Transwarmer or exothermic mattress	The Cochrane review reports meta-analysis of two studies (119 infants) comparing plastic bags and thermal mattresses with plastic bags alone for infants <31 weeks gestation[3]. Results showed improvement in core body temperature on admission to the NICU or up to two hours after birth but with an increase in elevated temperature. NB: Manufacturer safety guidance recommends these mattresses should not be used in conjunction with other heat sources due to the risk of overheating and the rare but potentially serious risk of severe burns. Units who choose to use transwarmers should be aware of this guidance. Strict vigilance must be undertaken to ensure skin integrity, to avoid hyperthermia by continuous temperature monitoring and to limit the duration of use particularly in the context of radiant heat.
Radiation	Non direct transfer of heat to cooler mediums	Radiant heat source	Recommended as standard care by ILCOR and UK Resuscitation council[4, 24].

Overview of the Improvement Journey

The following table shows the steps that are commonly taken on an improvement journey. Each step is discussed further in subsequent sections.



Phase	Approach	Methods and Tools	Outcome
1. Define the problem	Identify the problem and how large it is	Forcefield analysis Fishbone diagram Case review Process mapping Pareto chart Learn from experts Driver diagram	Define the problem, diagnose why the problem occurs and what improvement would look like
2. Develop a shared purpose	Form a team of enthusiasts	Engaging a team Engaging stakeholders	Establish a shared objective and a culture for change
3. Plan and implement changes	Formulate, prioritise and test solutions	Project Charter QI Methodology	Complete a formalised plan of proposed improvements
4. Test and measure improvement	Test, review and re-test improvements	Measurement Run chart Statistical Process Control Chart Days between Chart	Determine whether improvement has resulted in change
5. Implement, embed and sustain	Implement widely and ensure sustainability	Education Communication Motivation Governance	Shared learning and embedding changes into practice

Phase One: Define the Problem

Where are we now?
It is important to understand not only your local data, in this case the number and proportion of inborn babies <32 weeks with a temperature outside of the normal range within the first hour, but to consider it in the context of national standards (NSQI 12) and to observe any changes over recent years.

Find out for babies <32 weeks who are born in your unit:

1. Timing of temperature measurement?
    a. How many babies have their temperature recorded within an hour of birth?
    b. How many measurements are taken later than one hour after birth?
    c. How many measurements are not taken or are missing?

2. Rate of normothermia
    a. What proportion of babies are in the normothermic range (36.5-37.5°C)?
    b. What proportion of babies are below 36.5°C?
    c. What proportion of babies are above 37.5°C?

3. It may also be useful to ask:
    a. Is your data both accurate and complete?
    b. How has your data changed over time?
    c. How does this compare with the UK average?
    d. How does this compare with other units in your network?
    e. How does this compare with other units of similar size and acuity on NNAP Online (https://nnap.rcpch.ac.uk/unit-data.aspx)?

How did we get here?
There are many tools to help your team understand why babies get cold in your unit. You do not need to use all of these tools but should explore which of these exercises works best for your team (NSQI 13). All of these tools are explained further in the BAPM QI Made Easy pages ('Investigating your Current Practice' www.bapm.org/pages/58-qi-made-easy)

1) ***Forcefield analysis-*** this tool balances the positive and negative drivers influencing admission temperature and scores assigned to describe the strength of each force. Study, plan and act to strengthen the weaker positive forces and diminish the resisting forces (Figure 2). A template can be found in Appendix 1.

2) ***Fishbone diagram***- cause and affect analysis tool. This is a useful tool for categorising factors which influence admission temperature (Figure 3). A template can be found in Appendix 1.

3) ***Case review*** – take the last 10-20 cases of admission hypothermia and using a structured review tool (Appendix 1), identify any common themes. Consider reviewing 10 cases where normothermia was achieved and identify strengths.

4) ***Process mapping***- think about the journey that the baby takes from delivery through to admission and think about the factors within the process and the environment that may contribute (Figure 4).

5) ***Pareto Chart-*** in categorising the underlying problem, a pareto chart gives a visual depiction of the frequency of problems in graphical form, allowing you to target the areas that offer the greatest potential for improvement (Figure 5).

Figure 2. An example of a forcefield analysis for normothermia

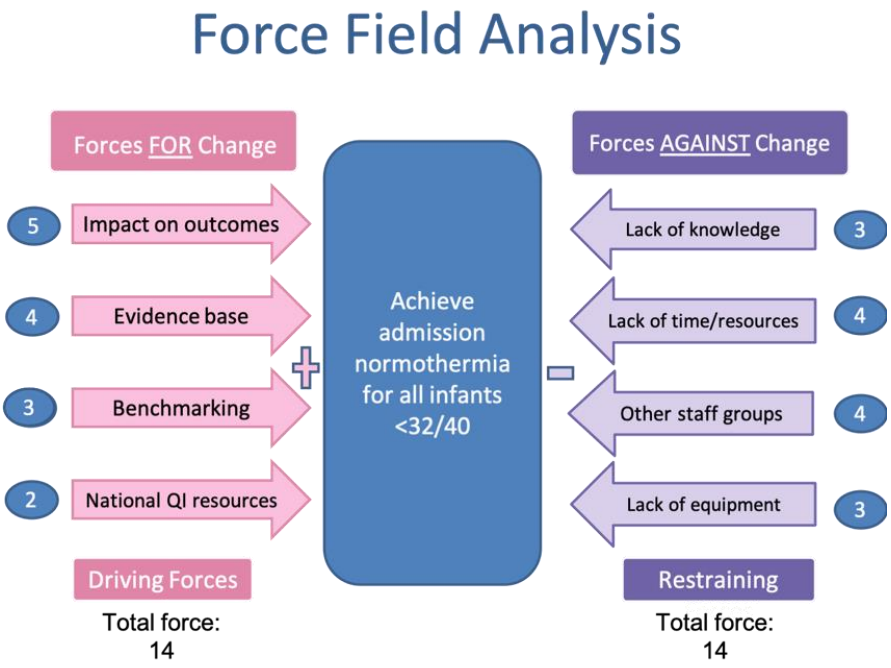


Figure 3. An example of a fishbone diagram for normothermia

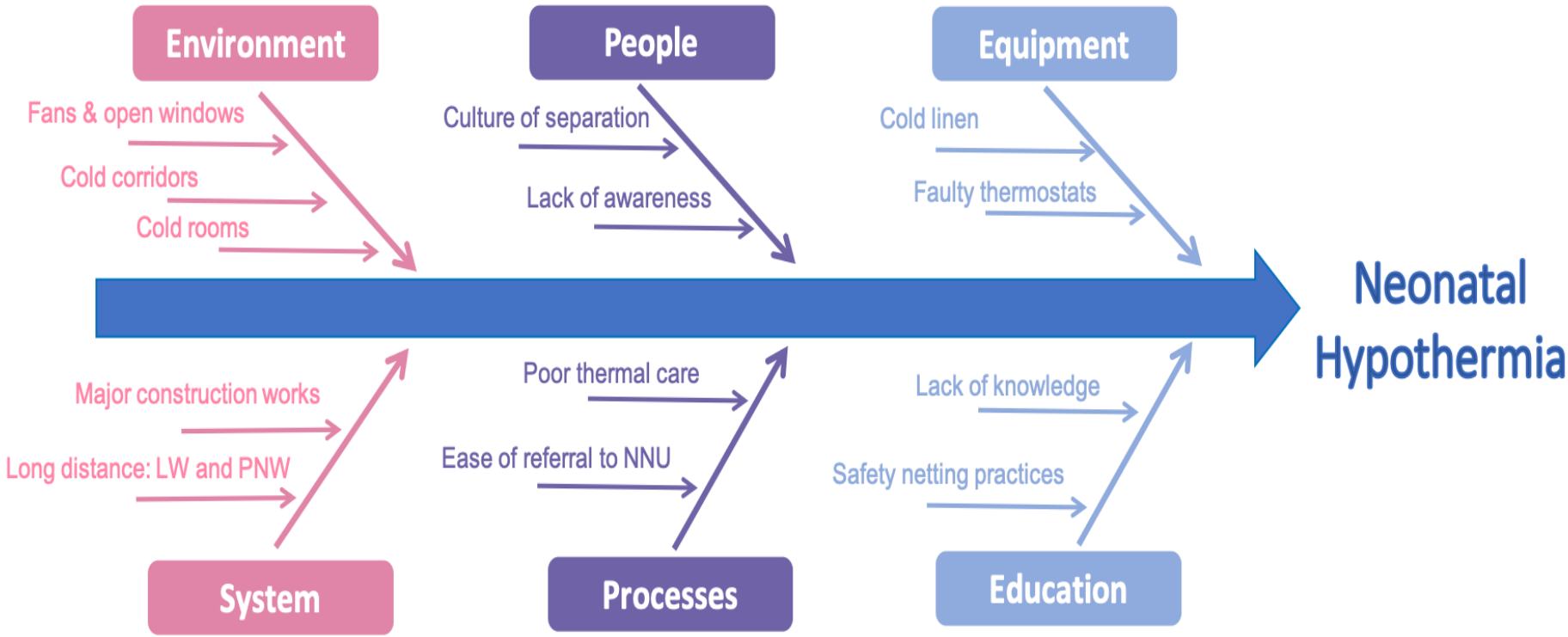


Figure 4. Process mapping a baby's temperature journey

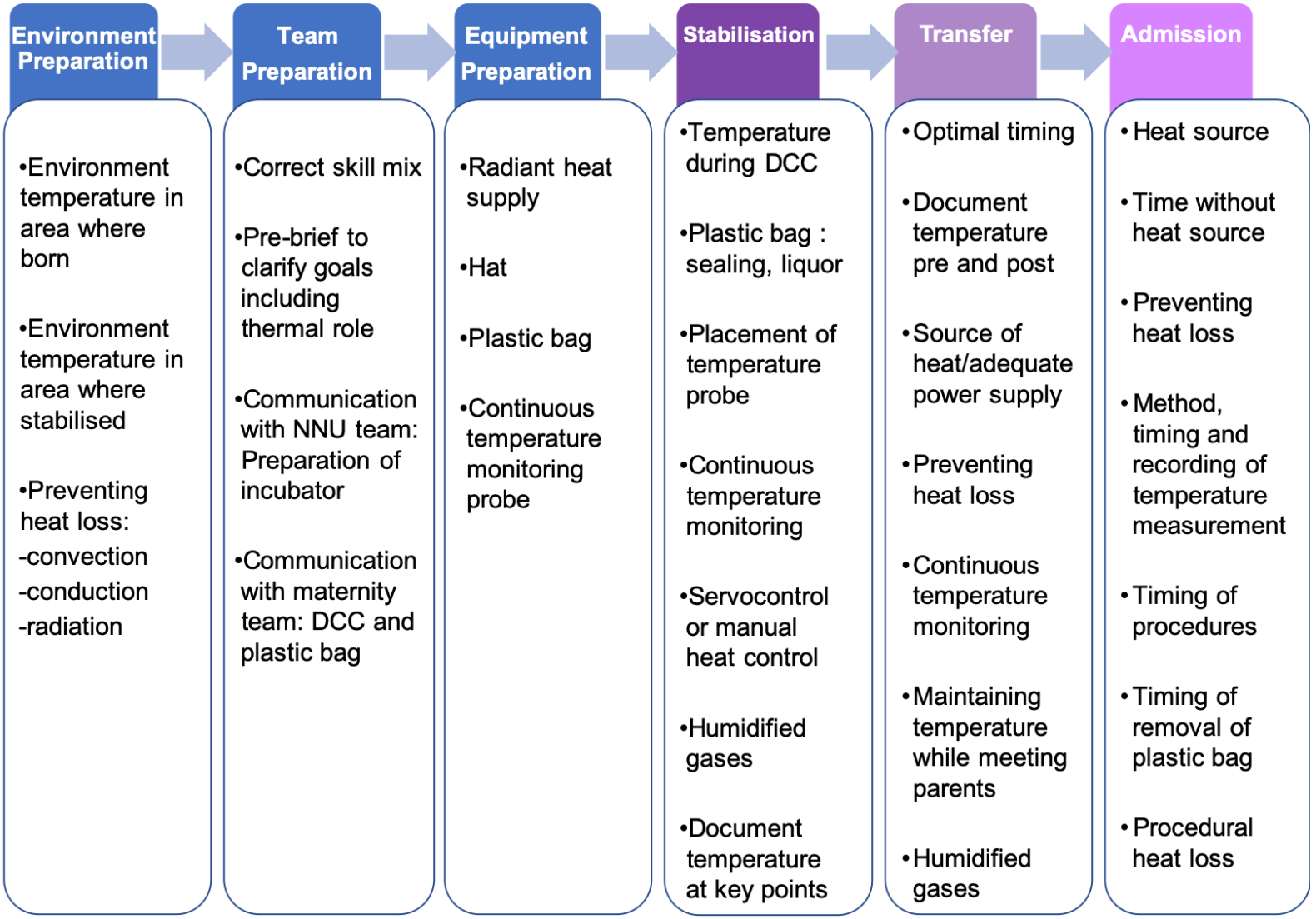
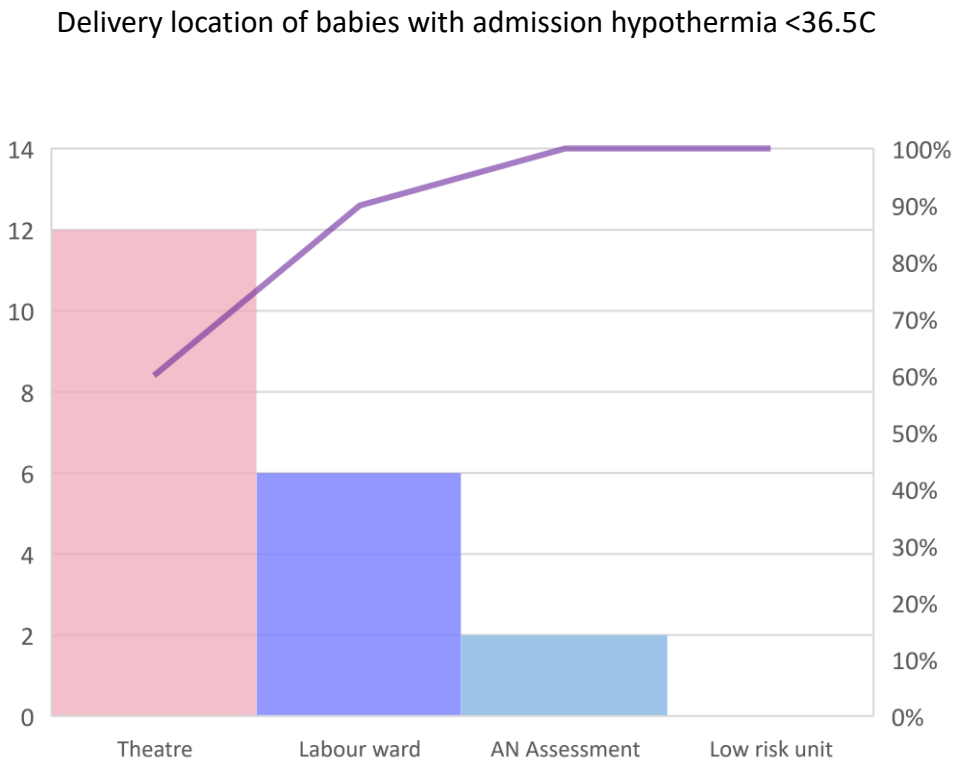


Figure 5. An example of a pareto chart for investigating normothermia

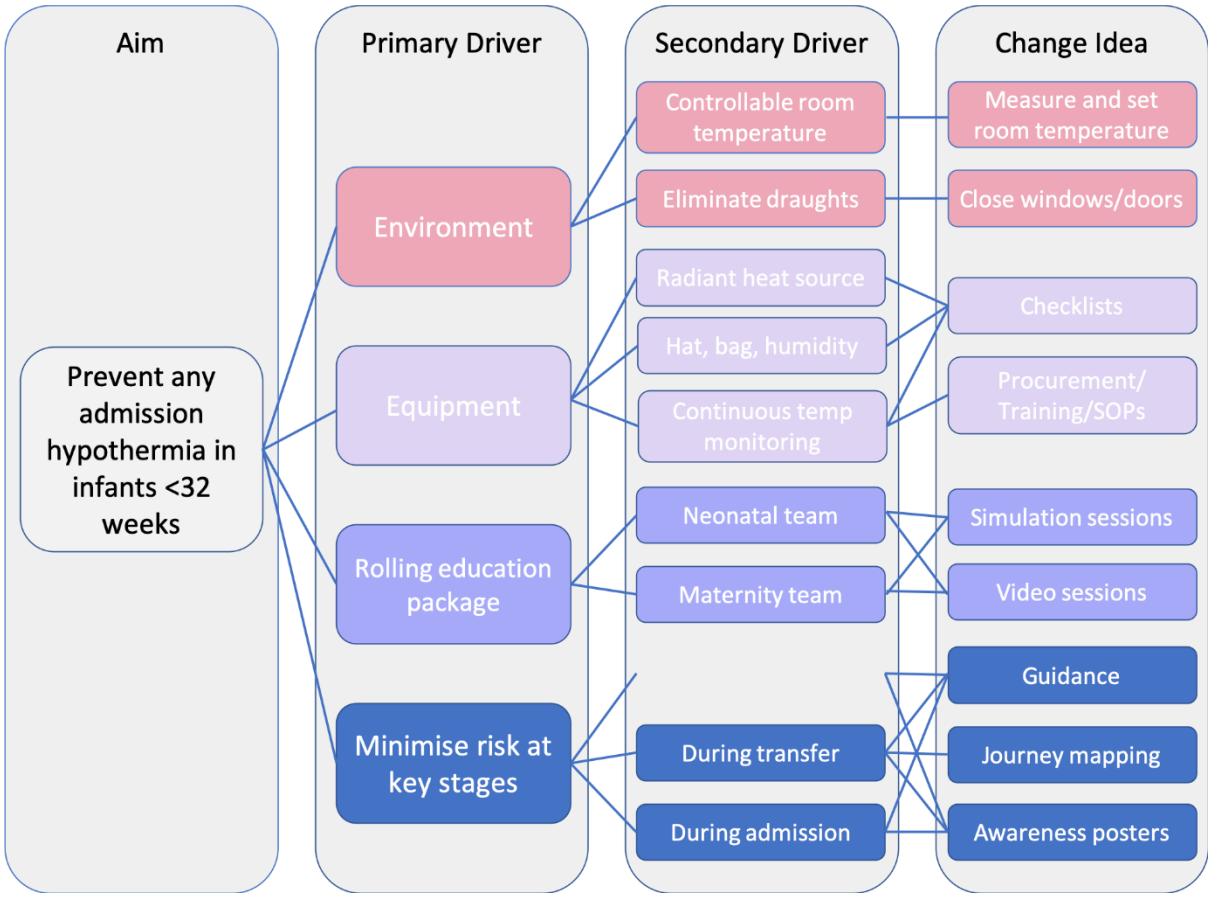


The Improvement Plan

Using one or more of these tools will identify potential areas for improvement and ideas for change. These ideas can be pulled together into a driver diagram (Appendix 1) to allow you to apply a clear and organised structure to your project (Figure 6).

In developing your driver diagram, both the BAPM and the NNAP strongly recommend that as part of a change programme to improve normothermia, a thermoregulation care bundle is developed with multidisciplinary input, and that this mandates the use of evidence-based strategies to encourage admission normothermia of very preterm babies.

Figure 6. An example of a driver diagram to improve normothermia



Learning from the experts

It can also be helpful to speak to other units about how they have tackled low rates of normothermia. High performing units and those who have made significant improvements over time can be identified from NNAP online (https://nnap.rcpch.ac.uk). A number of these units have shared their learning below.

Alan Fenton, Royal Victoria Infirmary, Newcastle

We encouraged people to be proactive about turning the heating up early
We increased the temperature on the under-patient mattress by a degree
We worked hard on ensuring babies not lying in pools of cold liquor in plastic bags and made sure the bags were applied and sealed appropriately
We actually recorded the data accurately in Badger

SHIP QI Project: Alok Sharma, Princess Anne Hospital, Southampton

We used a larger plastic bag
Servocontrolled temp regulation throughout neonatal resuscitation and recording temp before and after transfer
We encourage use of transwarmers for births in certain situations
We formalised the resuscitation practice and allocating role of thermoregulation to one person
We have embedded this in neonatal simulation and deliberate practice

Hot on Cold Babies Project: Tristan Bate, Hillingdon Hospital

We have *Hot on Cold Babies* checklists on resuscitaires
Temperature covered frequently in inductions and weekly MDT simulation sessions
Early check of temperature at resus and early use of transwarmers
Dashboard / NNAP results of admission temps are shared with staff regularly

Unfortunately in 2018 our results were not as good and we are reviewing or procedures- for instance the fact our transport shuttle is out of action may be contributing

Huw Jones, Queen Alexandra Hospital, Portsmouth

We have a group of motivated nurses
We have a collective responsibility
Room temperature is optimised for baby (aiming for 26C) and not staff comfort
We use Transwarmers (not plastic bags) for all infants <29 weeks in the delivery room, during admission to NICU and in many cases while lines are placed
There is a warmed towel on the scales on NICU
A Datix form is raised if temperature is outside the normal range and care reviewed to ensure any lessons are learnt

Phase Two: Develop a Shared Purpose

"Those most affected by the change have the greatest interest in designing it in ways that are meaningful and workable for them" [31]

Engaging your team

One of the key components to any successful project is having an implementation team that are engaged, resilient, enthusiastic and committed to working together to create the right culture for change (NSQI 2, NSQI 15). Teams should ideally be around 4-8 members and include:

- A Neonatal or Paediatric project lead (can be medical or nursing)
- Multidisciplinary representation including neonatologists/paediatricians, neonatal nurses, midwives, obstetricians, labour ward and theatre representatives
- Aim for parent representation (NSQI 10)
- People with QI expertise ideally (NSQI 17)

When forming your team consider:

- **Who** are the most influential people within the maternity/neonatal team – these are often not the most senior staff members?
- **Where** are the areas likely to be affected by any changes – do you need to engage staff from outside of your unit team, for example theatre staff, maternity staff?
- **Why** should people want to be involved in your project – share your vision and think how you are going to engage people and maintain their commitment?[24]
- **What** is your expectation of team members – what will they be required to do in terms of time and effort?
- **How often** will you meet? **When** are people available and are your time commitments realistic?
- **What else** is going on? Are there existing workstreams with overlapping agendas that could be pulled together to prevent duplication. Are there other QI projects which may have to take priority?

Find out if your local hospital has a central improvement team who can facilitate projects and provide valuable skills and knowledge in designing and implementing improvement work. Local data analysts may also be useful in helping to collect, analyse and display data.

Stakeholder engagement - Who else needs to be involved?

Start by brainstorming the groups of people likely to be affected by the proposed change (NSQI2). Within the topic of normothermia, they are likely to include:

1. Senior and junior paediatricians
2. Neonatal nurses
3. Midwives
4. Obstetricians
5. Theatre staff

These groups need to be:

1. **Prioritised**- in terms of the power they have to make your project succeed or fail
2. **Understood**- how are they likely to feel or react to the proposed changes?
3. **Informed**- devise a communication plan to sustain interest and win over doubters. This plan should include modalities of communication (eg presentations, emails, newsletters), frequency (monthly, weekly, daily) and key messages you want to deliver.

It is a worthwhile activity at this stage to review the context in which you wish to implement your changes. Although the changes you wish to implement have been successful elsewhere, differences in the culture and the context between units may result in variable results. Useful information can be obtained from the results of your Safety Culture Survey which may indicate how well staff feel listened to, how ready your unit is for change, or what might be needed to optimise communication.

Phase Three: Plan and Implement Changes

Project Charter

It can be useful to construct a Project Charter at the start of this phase (https://improvement.nhs.uk/documents/2145/project-charter.pdf or https://learn.nes.nhs.scot/3315/quality-improvement-zone/qi-tools/project-charter) to detail your proposed improvement, including the resources required and the potential benefits to patients. A Project Charter is a format endorsed by many Trust Improvement Teams and will provide direction and a sense of purpose, and may give your project increased leverage with management.

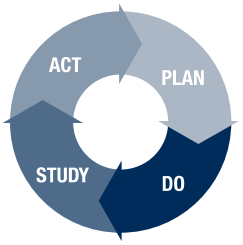
Formulate, prioritise and test solutions

There are a number of methodologies that can be adopted to implement a quality improvement strategy, for example Lean, Six Sigma and the Model for Improvement which all draw on a similar set of principles tools[32]. No single quality improvement method is better than others; what matters more is having a consistent approach that you are familiar with and skilled in applying. The Model for Improvement is a widely recognised approach within healthcare and is frequently associated with positive outcomes for improvement and will be used here as an illustration.

The Model for Improvement

Ask yourself:

- What is it you want to achieve?
- How will you know that a change is an improvement?
- What changes can you test that will result in an improvement?



For each change idea, a PDSA cycle can be used:

Plan

- Which intervention(s) to try first? This may be the intervention most likely to make an impact, the easiest to implement or the one that will best win hearts and minds.
- How will this intervention be introduced into clinical practice?
- Who and what will be required to make this happen?
- Predict what you think the change might be?

Do

- When and how will this plan be carried out? A timescale is useful. Document problems and unexpected observations.

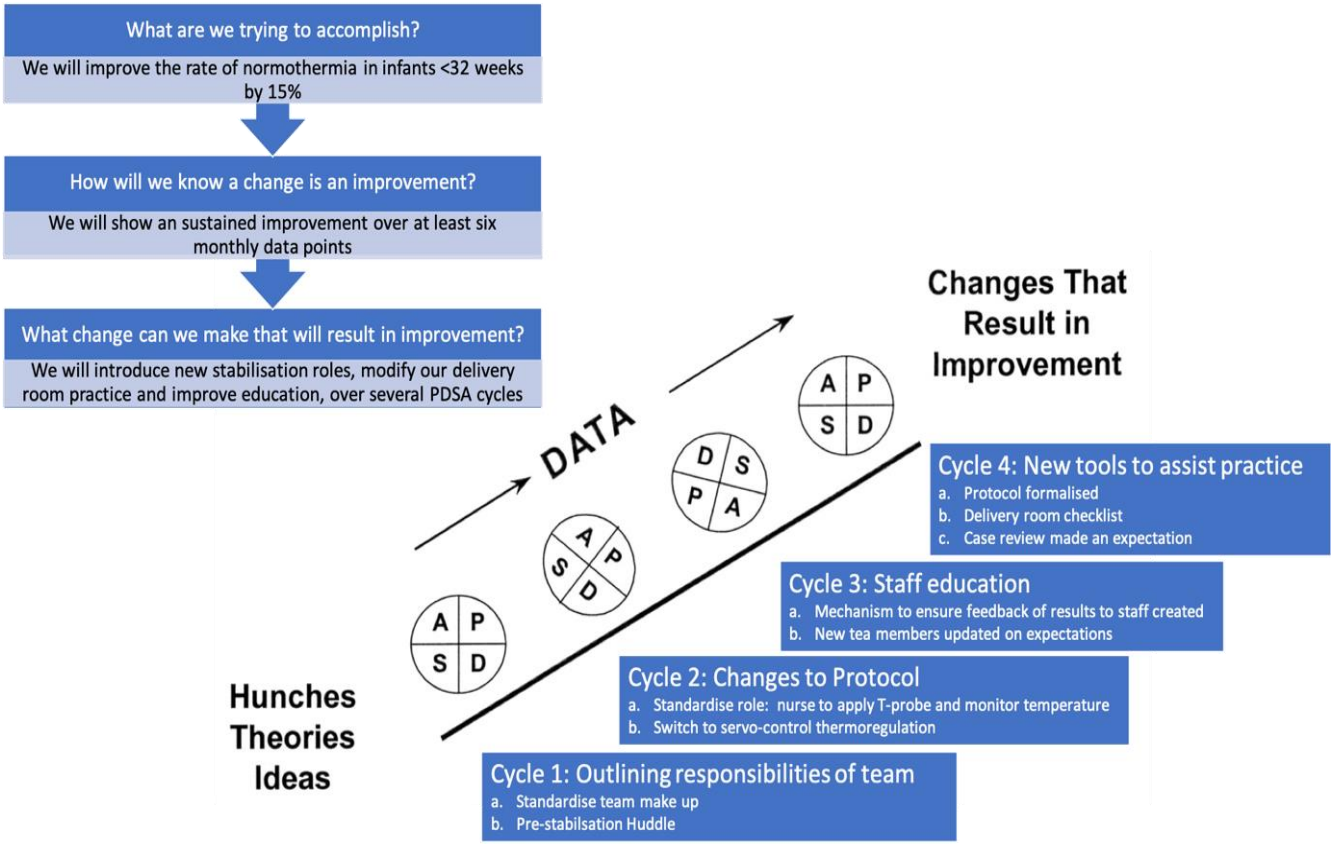
Study

- Use established tools to analyse your data (see Phase 4). Has your change idea resulted in improvement? Is this a real improvement? Does your data suggest your change idea needs modified? Why might this be so? Compare your data to your predictions.

Act

- Identify and carry out any modifications needed to this change idea to make it more effective, using further PDSA cycles as needed i.e. Adapt, Adopt or Abandon

Below, the Model for Improvement is used to work through an example of implementation in normothermia. More information on using the Model for Improvement can be found on the BAPM QI Made Easy pages ('Planning your Change Idea' at www.bapm.org/pages/58-qi-made-easy).



Phase Four: Test and Measure Improvement

In this phase improvements are tested, reviewed and re-tested in order to find a solution.

Data collection

Measuring for improvement is different to the data collected for research or to prove whether clinical interventions work or not. This type of measurement asks the questions 'how do we make it work in our context?' and 'how do we know that a change is an improvement?' It is important that you collect the right data for your project (NSQI 1). Further information on selecting your measures can be found on the BAPM QI Made Easy pages ('Planning and Implementing Change' www.bapm.org/pages/58-qi-made-easy)

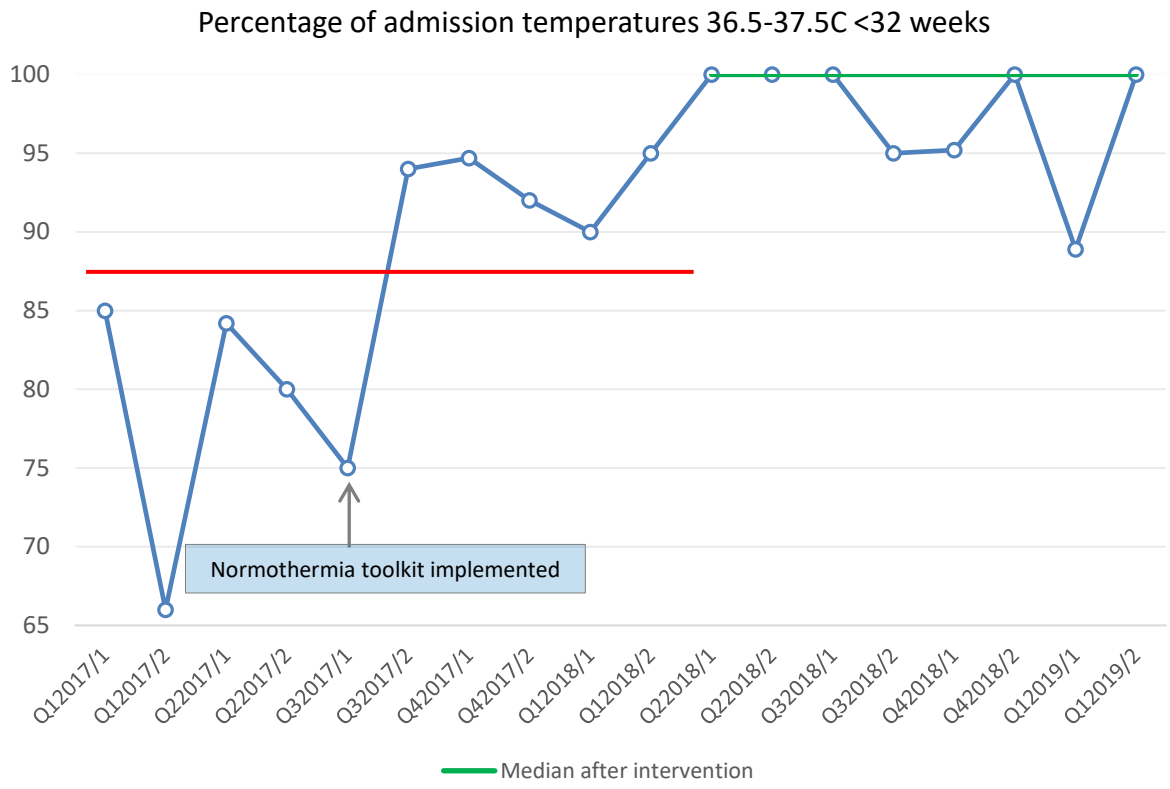
1. **Outcome measures:** reflect the impact on the patient e.g. the admission temperature
2. **Process measures:** the way systems and processes work to deliver the desired outcome e.g. the proportion of times a plastic bag is applied; the environmental temperature. Process measures audit compliance with your change ideas
3. **Balancing measures:** this is what may be happening elsewhere in the system as a result of the change e.g. by avoiding hypothermia there may be an increase in elevated infant temperatures; by increasing room temperature more mothers may meet the criteria for Sepsis 6.

Data analysis and display

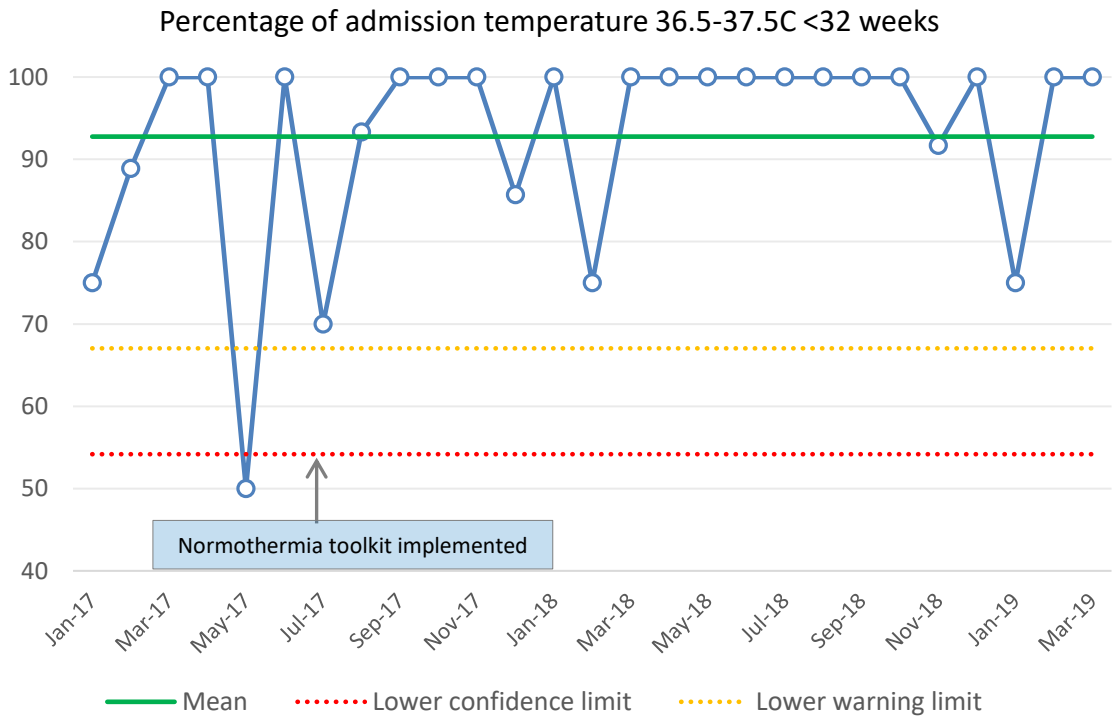
How will any change be measured, assessed and displayed? Common tools to present and analyse your data include run charts, statistical process control charts and days between charts (see examples below). All require a level of knowledge and skill to collate and interpret correctly. Importantly measurement should not be a 'before and after' audit which is unreliable in measuring true change, but a continuous process over time during which your changes can be evaluated and modified.

All of the options for analysis detailed below are explained in the BAPM QI Made Easy pages ('Interpreting your Data' www.bapm.org/pages/58-qi-made-easy). Note that the type of chart you choose will need to be understood by your audience. You may require an easy to read key to explain your chart or a summary interpretation.

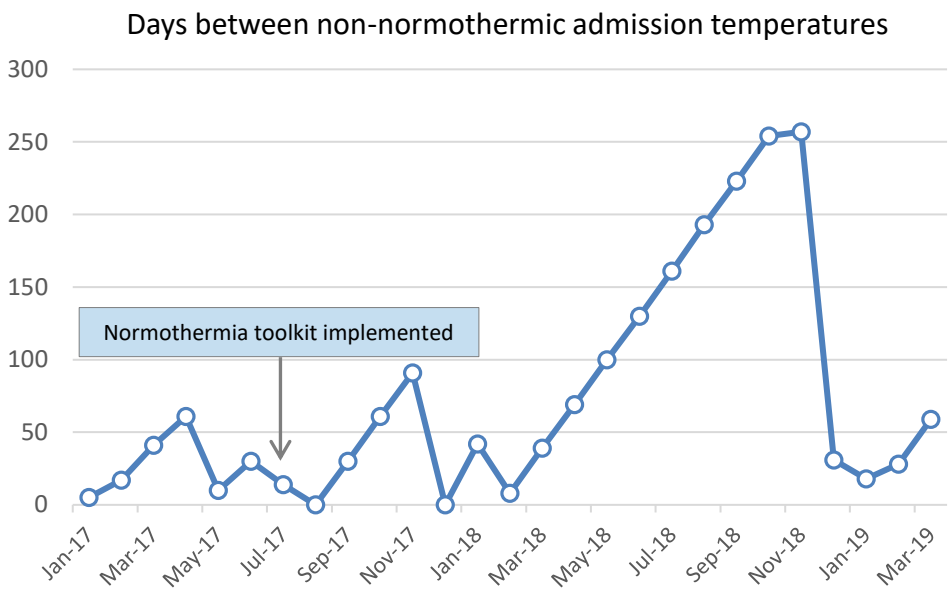
1. **Run chart**



2. **Statistical Process Control Chart**



3. **Days between chart**



Phase Five: Implement, Embed and Sustain

This phase involves the wider implementation of improvements such that change becomes embedded in routine practice throughout the system and is sustained with governance arrangements.

Spread

This can involve formal methods such as *dissemination* that includes presentations, publications, leaflets, some of which may have limited reach within your department; or informal methods of *diffusion* where word of mouth, champions and opinion leaders can accelerate your message. Consider carefully what is required for the embedding of changes within your service (NSQI 2, NSQI 18).

Exception reporting

Both the BAPM and the NNAP recommend that neonatal units should report all cases where the admission temperature of a very preterm baby is below 36.0°C using local risk reporting mechanisms, and consider a policy of reporting all babies with admission temperature below 36.5°C (NSQI 13). The case review tool (Appendix 1) can be used or adapted for this purpose.

Barriers and loss of motivation

It is not unusual to find the size of a previous improvement lessen over time. It is important to understand why so that solutions can be tailored to the problem. Different approaches will be effective for different people and different situations. The following activities may be useful: talk to key individuals, observe clinical practice in action, use a questionnaire to survey staff, brainstorm with a focus group. Education is a key element of overcoming barriers particularly within an interactive forum; using opinion leaders to influence others within your staffing structure; reminder systems to prompt clinicians; and ensuring feedback of data to staff in a format that they find useful; all these can help to reinvigorate and embed your changes for improvement (NSQI 2, NSQI 18).

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