Statistical Process Control (SPC) Charts:

Spotting the signals from the noise

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An Introduction to SPC Charts

Statistical Process Control (SPC) charts were originally developed in the 1920s and used for quality control within industry, but over the past decade or so they have been adopted by the NHS as a more subtle and informative alternative to RAG-rated tables.

The advantage of SPC charts is that they allow users to look past the 'noise' of expected variation to easily pick out results that would not be expected in the normal process, and which therefore require investigation. These unexpected results are known as 'special cause variations'.

Using a practical example, if we were recording the length of time of a daily commute to work, a normal variation would be traffic delays or red traffic lights – these are common, expected causes of delay that should reasonably be allowed for within the process of the commute. A special cause in this case would be a flat tyre – this is an unexpected event which disrupts the process of the commute.

Going back to our SPC charts, using historical data and statistical methods it is possible to determine what variation is normal and to be expected, and to instead focus on identifying special cause variations. These include values outside of the expected range; runs of values above or below the average; and ongoing trends of improvement or decline. Once a special cause variation is identified, it should prompt an investigation into what has happened and why.

SPC charts can also show whether or not a target or standard is achievable within the current process, and therefore throw a spotlight on where quality improvements are best targeted.

SPC charts may look forbidding at first, but once you learn how to interpret them, they become more friendly, informative, and intuitive.

The network SPC charts have been adapted from standard NHS SPC charts, using the same format and colours, but adding in some extra features, such as a graph to show eligible numbers and missing data, and a description of the eligibility and compliance criteria.

What follows is a simple guide to our network SPC charts. If you would like more information on SPC charts and their use in NHS settings, there are more detailed documents on the NHSE Making Data Count website

Elements of SPC Charts

There are various elements to SPC charts, but the basis is a run chart – a line graph of data plotted over time.

Axes and data

On our network SPC charts, data is presented monthly, with months shown along the horizontal (x) axis. Most of our charts show the compliance rate to NNAP or BAPM metrics, so percentages are shown on the vertical (y) axis. **Compliance is plotted against these axes as a dark blue line**. The graph below is a run chart of network compliance to the *extreme preterm births in a NICU* metric:
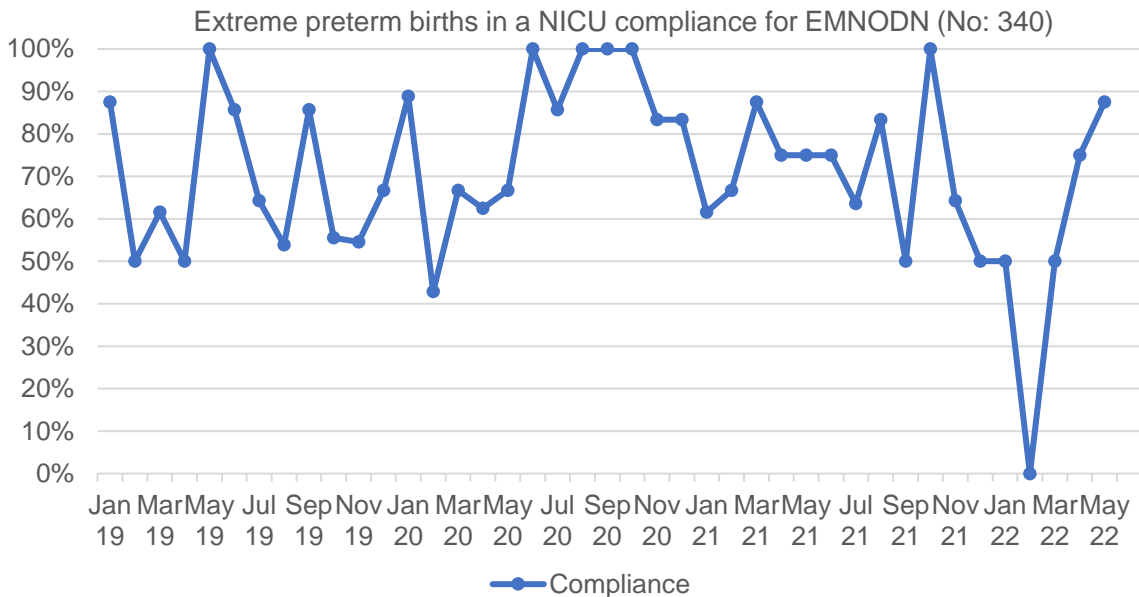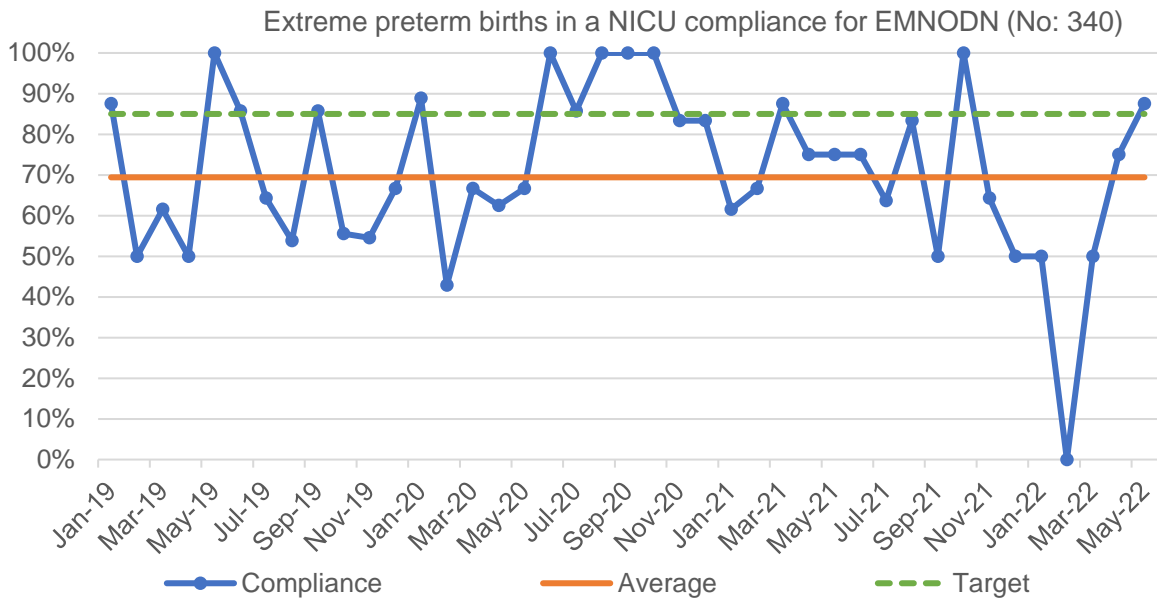

Average line

Running through the middle of the compliance rate, **an orange line shows the overall average (mean) compliance**:
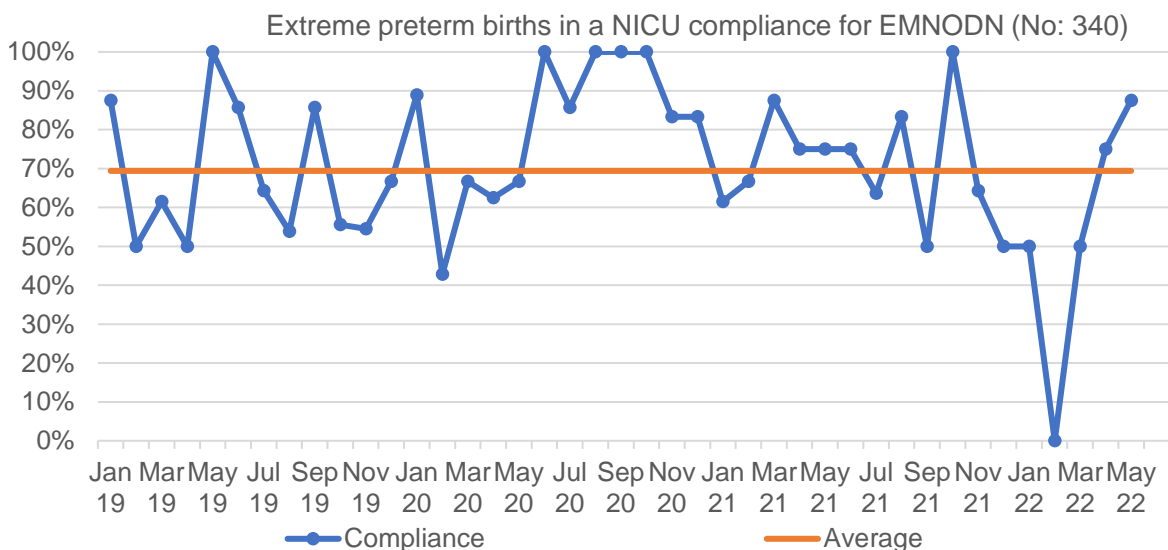
Target line

A target may be added – on the network graphs, **standards set down by NNAP or BAPM are used where available, and are represented by a green dotted line**:

## Control limits

Control limits show the range of values to be expected within normal variation. The graph below shows that the network compliance to the *extreme preterm births in a NICU* metric is expected to be between around 18% (**the lower control limit – an amber dotted line**) and 100% (**the upper control limit – a grey dotted line**). Any value within this range is considered normal.
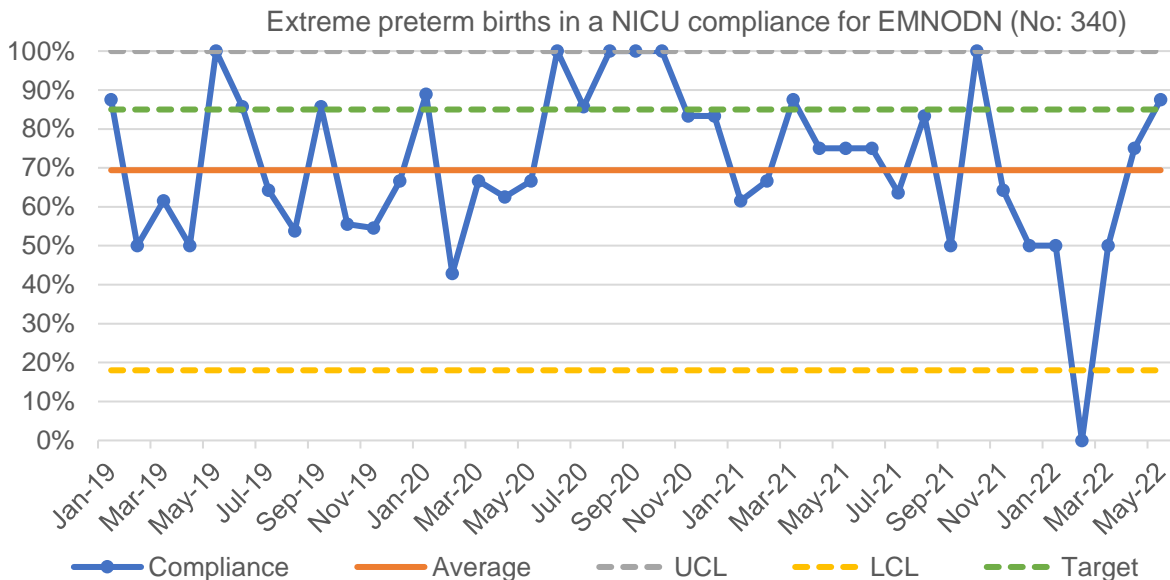
Special cause identification

The final element to the SPC chart is the identification of special causes – **data points that show performance better than expected are coloured light blue**, and **data points showing performance worse than expected are coloured orange**. On the chart below, a run of seven points above the average is highlighted (Jun to Dec 20), as well as a data point below the lower control limit (Feb 22). We will look at possible reasons for these in the following section.

Extreme preterm births in a NICU compliance for EMNODN (No: 340)
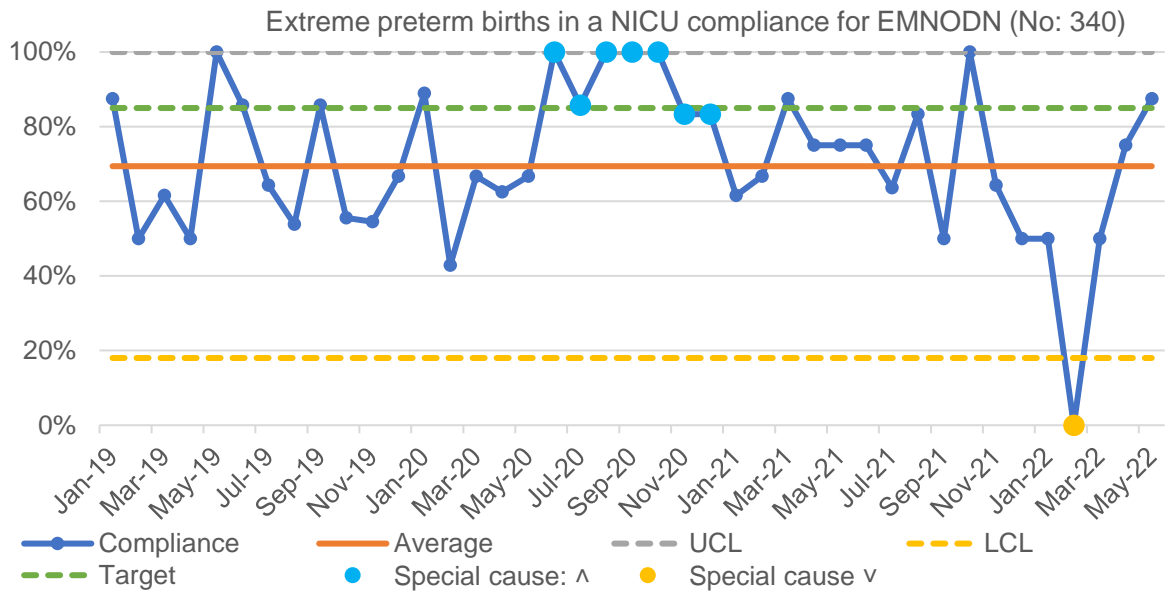
Additional Elements of Network SPC Charts

Count bar chart

Because the numbers of eligible babies / mothers are low, especially at unit level, it is useful to know how many cases there are. So we have added in a bar chart below the SPC chart, for the same period of time, that shows the total numbers eligible for each month, and also highlights cases where there are missing data that, if completed, may improve the compliance rate. As an example, the graph below shows numbers of eligible mothers and missing data for intrapartum antibiotics.
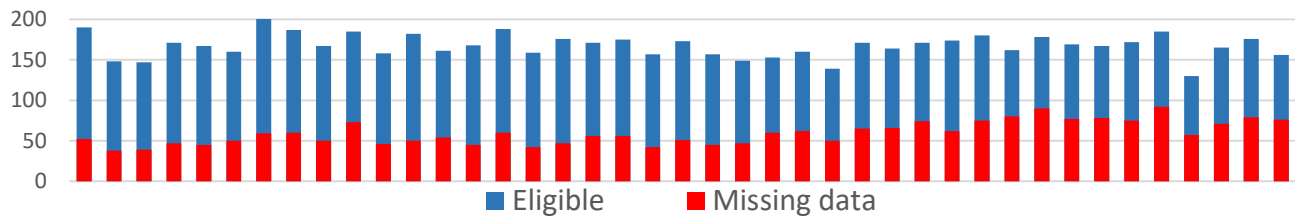
Metadata

The final element of the network graphs is a description of the source of the metric, the criteria for compliance (numerator), the criteria for eligibility (denominator), and the current status of the measure. Below are the details for extreme preterm births.

NNAP: 85% of babies born <27/40, <800g, or multiples <28/40 should be delivered in a maternity service on the same site as a NICU

N: 1st episode of baby born in period at <27/40, <800g, or multiples <28/40, multiples excluded, who were born in a NICU

D: 1st episode of baby born in period at <27/40, <800g, or multiples <28/40, multiples excluded

**Status: within control limits, average below standard**

How to Use the Network SPC charts

Looking again at the extreme preterm charts, the first thing to note is that the current month's compliance is within the control limits, and it is not part of a special cause variation.

However, the average is just under 70% against an NNAP standard of 85%, indicating that the network will not consistently achieve that standard without a change in process.

Looking at special causes in previous periods, there was a run above the average from May to December 2020. This is likely due to low numbers of extreme preterm births during periods of lockdowns – during 2020 there were an average of 6.5 extreme preterm births per month, compared to 9 per month in the periods before and after.

In March 22 there was a special cause value of 0% compliance, which was below the lower control limit of around 18%. Looking at the bar chart for the same period, there were only two eligible deliveries for March, so compliance could only ever be one of three values - 100%, 50% or 0%.
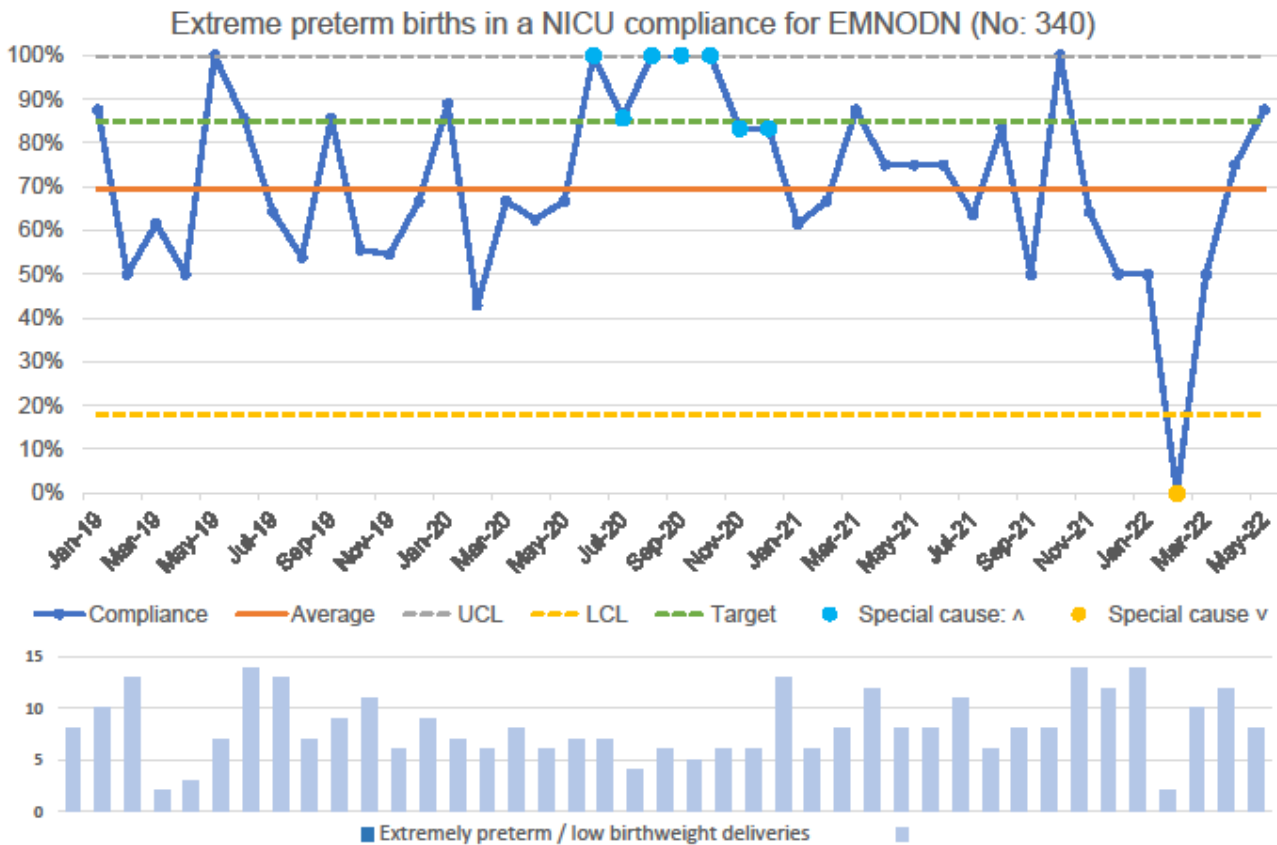
NNAP: 85% of babies born <27/40, <800g, or multiples <28/40 should be delivered in a maternity service on the same site as a NICU
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Status: within control limits, average below standard

One point to note is that the smaller the numbers, the wider the variation. The control limits on the IV antibiotics chart below, where eligible mothers are around 168 per month, are much narrower – between around 15% and 33% - than those on the extreme preterm births chart, where monthly numbers average around 8 eligible deliveries, and control limits are between around 18% and 100%.

IV intrapartum antibiotics compliance for EMNODN (No: 6877)
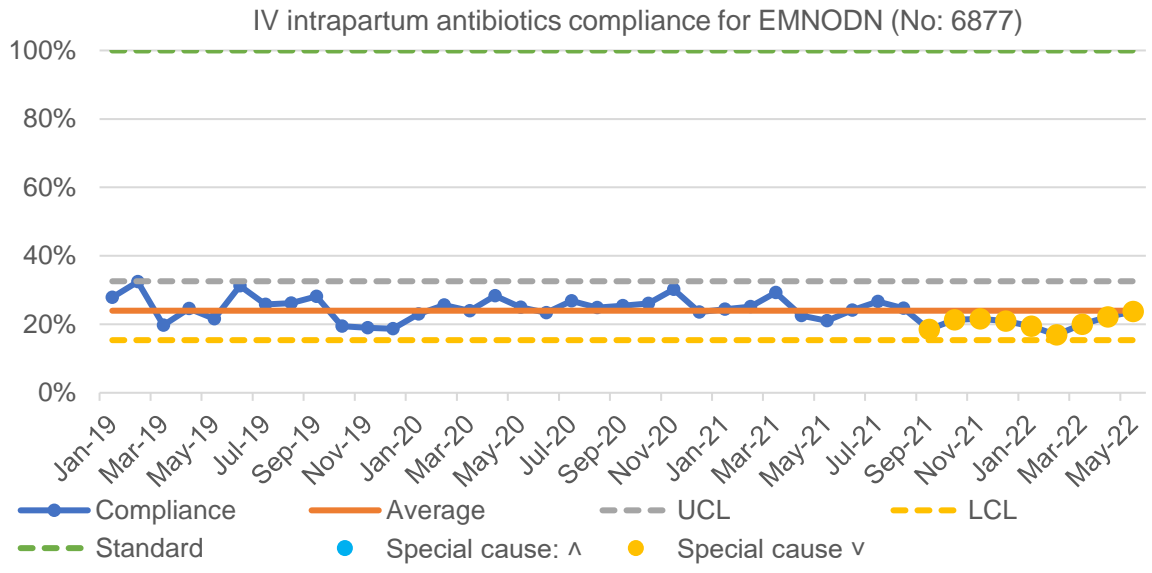
At unit level, this variation will be even more pronounced, and on some measures the control limits will be 0-100%, meaning that no value will be out of limits. This doesn't mean that SPC charts aren't helpful in these situations. On the contrary, they confirm that having 100% compliance one month and 0% the next is to be expected where the numbers are low, and encourage users to instead concentrate on looking for significant patterns of change, ie runs above or below the average, or trends of improvement or concern.

Limitations of SPC Charts

Like all representations of data, SPC charts are only as accurate as the data they are based upon. We hope that highlighting the extent of missing data will encourage units to initiate processes to ensure better data completion, especially for new metrics such as intrapartum antibiotic prophylaxis, and for metrics where the criteria for compliance has changed, such as antenatal steroids and antenatal magnesium sulphate. The source of the data for all these charts are data downloads, so the Badger IDs of eligible babies are available on request.

SPC charts work best if there are at least 20 data points and there is no obvious trend. Where this is not the case, a run chart may be used until that point is reached. For example, in 2021 NNAP introduced the new measure of delayed cord clamping. Since then there has been a period of induction, where the measure is gradually adopted, and compliance has continued to improve. So the chart for delayed cord clamping will be shown as a run chart until the process has settled. The control limits and special cause identification will be added once the process is established and compliance reaches an equilibrium.

Similarly, if a process is changed, for example if a quality improvement project has improved the compliance rate, or a change in how the metric is measured leads to a decline in compliance, the process controls can be recalculated. But again there needs to be a certain number of data points from the amended process to be able to do this, and in the meantime the graph is best displayed as a run chart.

Looking to the Future

At the time of writing, only a fraction of the reported measures have been converted to SPC charts, but more will be added in the coming months, with the intention that the current quality dashboards will eventually be withdrawn. In the interim period, SPC charts will be sent out alongside the existing dashboards.

As mentioned previously, we are hoping that the majority, if not all of the measures can be calculated from data downloads. This will enable us to have an oversight of the individual babies, and therefore to be able to provide a breakdown of patient-level data to units on request.

This will also be useful to support units looking at optimisation of care for the preterm baby, ie looking at the journey of each preterm baby to determine how many interventions they should have received and how many have actually been delivered. There is an increasing national focus on looking at quality measures in this way, and a network approach is particularly useful where babies have been transferred between network units.

While we know that some people looking at this data are completely comfortable with SPC charts, we are also aware that some people have no previous experience of these kind of graphs, and we are happy to answer individual queries, or provide informal training where required. For these, or any data queries, please contact the network data analyst:

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