RSPRT Guidance for Units

Contents

1 Introduction

Risk-adjusted resetting sequential probability ratio test (RSPRT) plots are used across many clinical settings and are accessible to Paediatric Intensive Care Units (PICUs) via PICANet. PICANet's primary method for identifying units that are performing better or worse than expected is the *Standardised Mortality Ratio* (SMR) metric. The procedure for calculating SMRs, and the annual process for identifying, confirming and responding to outlying values is covered in PICANet's Outlier Policy.

RSPRT plots have a similar purpose to SMRs insofar as they identify where PICUs have performance outside what might be expected given the case-mix of admissions. They have an advantage over SMRs in being calculated on an ongoing basis so that units can identify and respond to potential issues in a more time-sensitive fashion.

This document should be considered as an addendum to PICANet's main outlier policy and is intended to provide units with:

- a background description to the RSPRT plots
- interpretation of the plots and their three possible states
- the outline of a process to follow in case of a higher or lower than expected mortality rate
- a process to follow in the case of 'unable to assess' an RSPRT plot
- a case study from a unit that has dealt with an RSPRT outlier

Unlike the SMR which provides a comparison between observed and expected mortality, RSPRT plots are based upon a cumulative log-odds of mortality, and continues until the plot resets, at which point the cumulative log-odds are reset to zero. SMRs are presented graphically in a funnel plot in the State of the Nation Annual Report and detection of potential outliers follows a strict management process. The identification of higher or lower mortality rates than would be expected within the RSPRT plots are highlighted to the units by the PICANet team and units are asked to determine the rationale for this, with PICANet providing support at all times.

A key departure of this document from PICANet's main outlier policy is that the response to RSPRT signals is not prescriptive, given the variety of triggers and reasons for them. Nevertheless, full investigations by units are expected when they are advised to do so, with PICANet available to provide support.

2 RPSRT background

RSPRT plots present PIM3-adjusted mortality data on a cumulative basis and provide an indication that the provider may be heading towards becoming an outlier (having a higher or lower mortality rate than expected). These plots have the advantage of being in real-time, allowing any potential issues to be identified and quickly addressed. PICANet provide a quarterly update for each unit of their own RSPRT plots as a prompt to review any possible concerns.

The RSPRT plot represents a cumulative 'observed – expected' plot with horizontal thresholds[1]. It works on three components:

- A running test statistic (based on PIM3 and discharge status)
- Thresholds for the statistic that determines statistical significance
- Actions to be taken on crossing a threshold

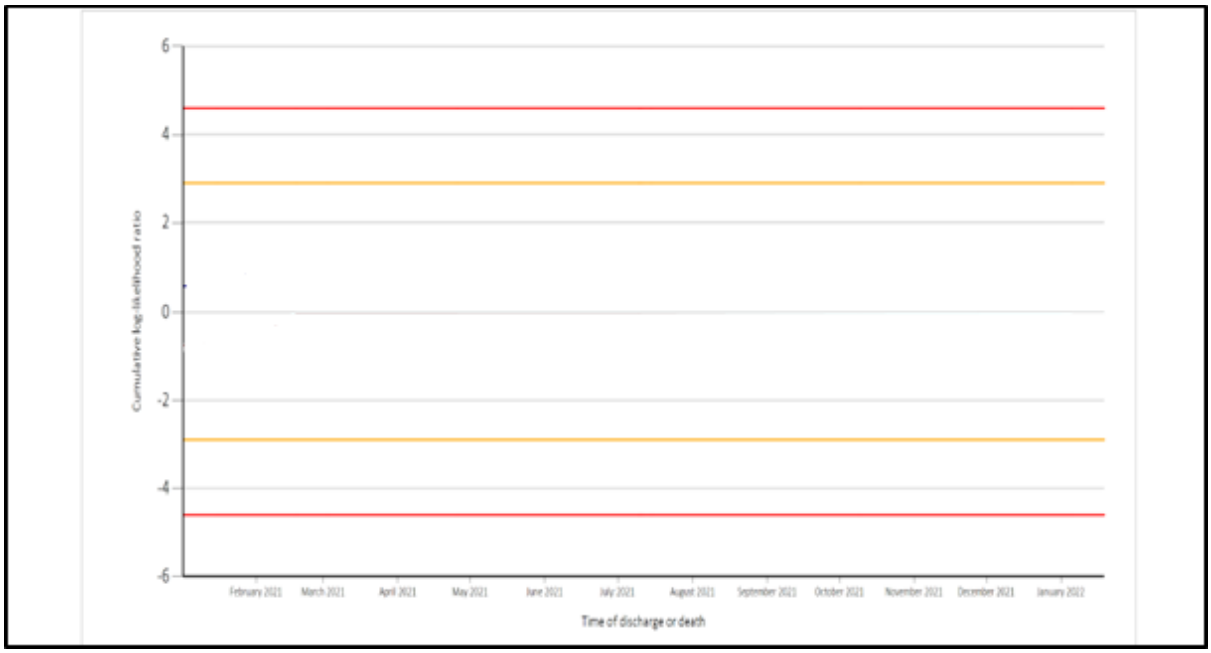
The running test statistic uses the Paediatric Index of Mortality (PIM3) score for each child on admission (note that this relies on a recording within the first hour of admission or during transport) and their discharge status (alive or dead), calculating the tests for halving or doubling the odds of mortality after each admission.

The thresholds (also known as 'Control Limits') have been set by PICANet taking into account Type I and Type II error rates. In Figure 1, the yellow line statistical significance value is set at $\alpha=0.05$, with the red line at $\alpha=0.01$. The area between these lines is the 'warning zone', indicating that the test statistic is beyond what would normally be expected. If the test statistic touches the red line, the chart resets, indicating a high probability that mortality rates are different from normal (i.e. high probability of rejecting the null hypothesis).

Actions to be taken by the units on crossing a threshold have been developed by PICANet in line with the Healthcare Quality Improvement Partnership (HQIP) published outlier guidance (2021).

[1] As described in Spiegelhalter, D. Grigg, O. Kinsman, R. Treasure, T. Risk-adjusted sequential probability ratio tests: applications to Bristol, Shipman and adult cardiac surgery, *International Journal for Quality in Health Care*, Volume 15, Issue 1, February 2003, pp 7–13, https://doi.org/10.1093/intqhc/15.1.7

Figure 1 - Blank RSPRT plot showing thresholds

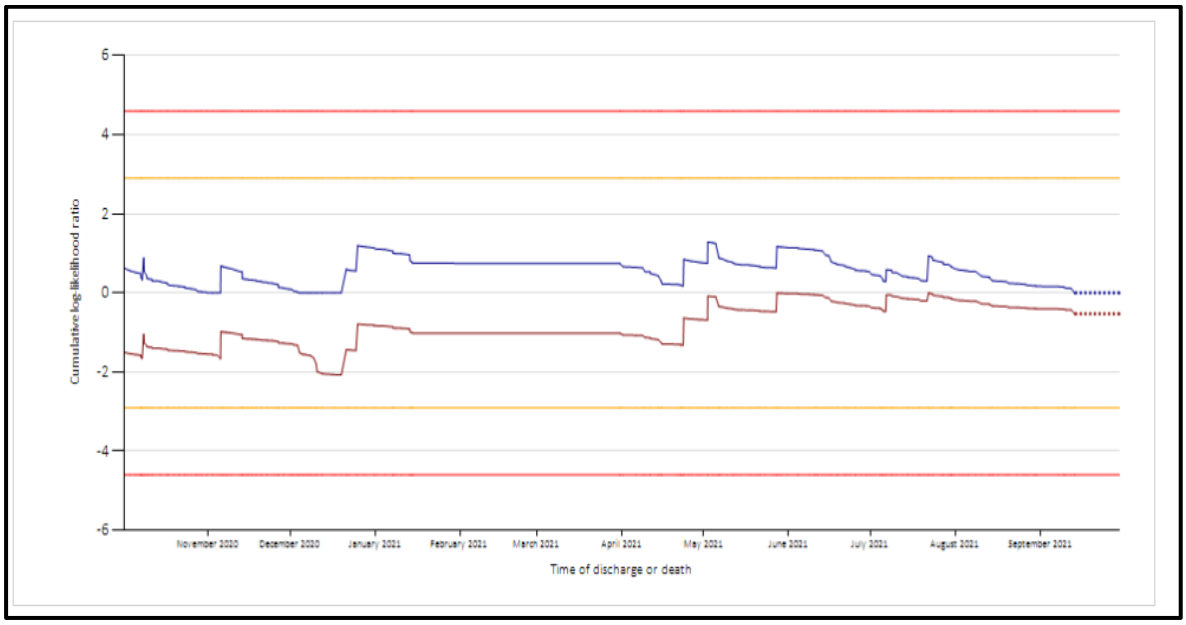


3 RSPRT plot interpretation

The RSPRT plot is presented in two halves. The top half of the graph refers to the odds of mortality doubling (indicating that the mortality rate is higher than expected) based on the prediction of PIM3. The bottom half of the graph refers to the odds of mortality halving (indicating that the mortality rate is lower than expected) based on the prediction of PIM3.

In addition to the thresholds shown in Figure 1, Figure 2 shows the upper (blue) line which indicates the log-likelihood of the odds of mortality doubling, and the lower (brown) line which indicates the log-likelihood odds of mortality halving. The blue line is always above zero, and the brown is always below zero.

Figure 2 - RSPRT showing upper (blue) and lower (brown) lines



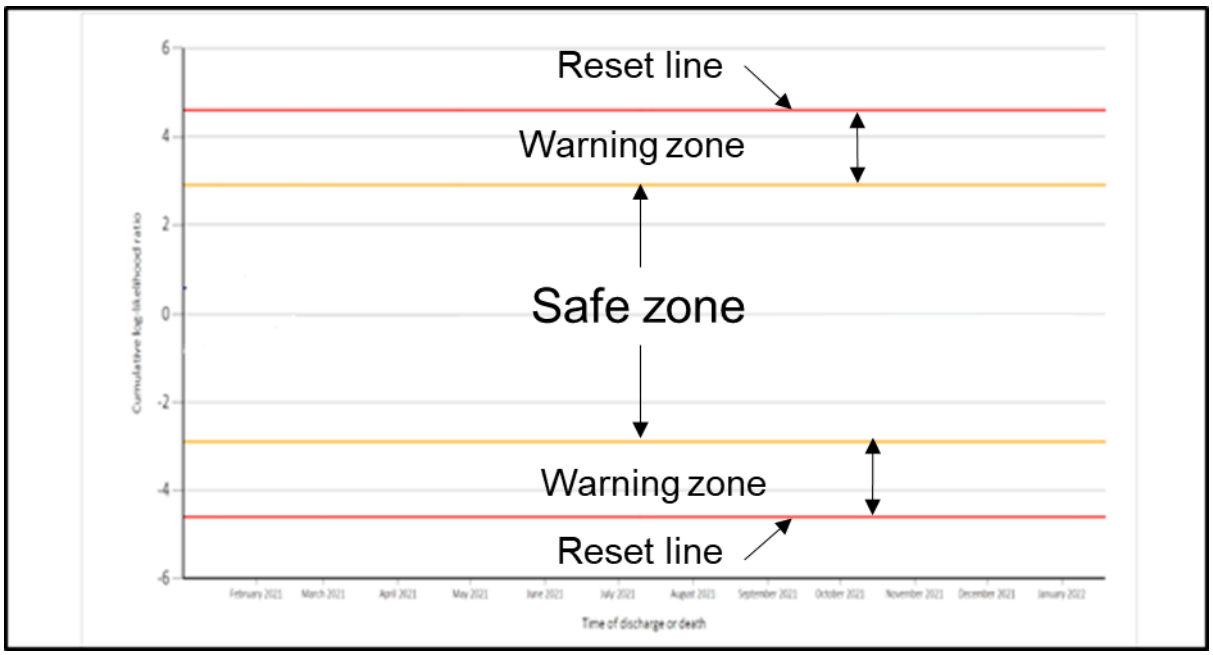
When a child is discharged alive, the top (blue) line on Figure 2 will move down by a small amount, until it reaches its minimum value at zero (a decreasing likelihood of doubling of odds). At the same time the lower (brown) line moves down as the likelihood of the odds halving increases as each child with a small expected probability of dying does not die. If a death at discharge does occur, the top (blue) line moves up, indicating an increased likelihood of the doubling of the odds of mortality. At the same time, the bottom (brown) line will also move up closer to zero.

The key elements are as follows:

- In between the yellow lines is the 'safe zone' representing the variability that you might normally expect over a twelve-month period.
- The area between the upper yellow and upper red line is defined as a 'warning zone', indicating mortality rates are temporarily higher than one would expect to see over a twelve-month period.
- The top half of the graph resets if the upper red line is touched or crossed.
- The area between the lower yellow and lower red line indicates mortality rates are temporarily lower than one would expect to see over a twelve-month period.
- The bottom half of the graph resets if the lower red line is touched or crossed.

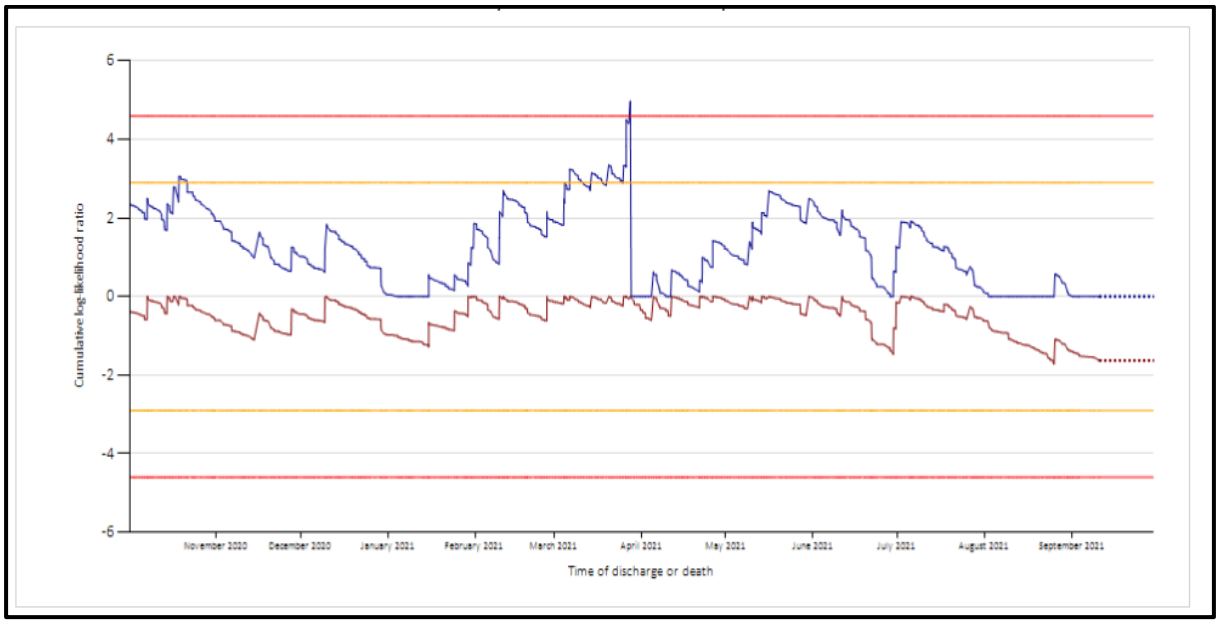
These areas of the chart are labelled in Figure 3.

Figure 3 - Areas of RSPRT plot



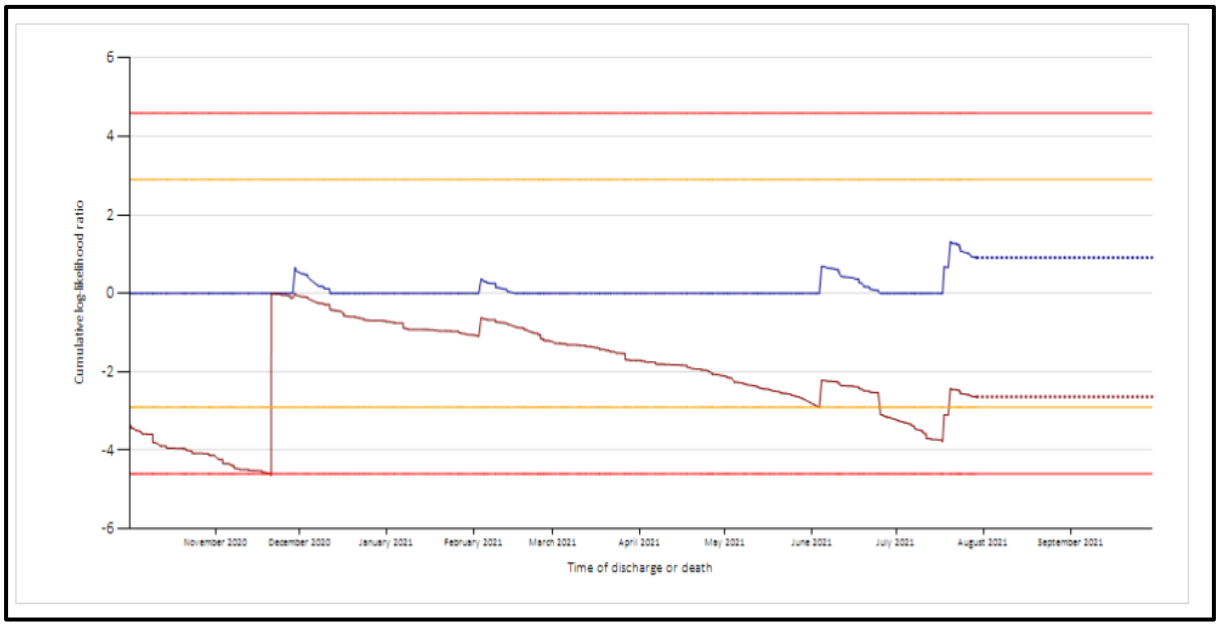
If the upper (blue) line crosses the upper reset line, this indicates that mortality rates are significantly higher than one would expect to see under normal circumstances. Crossing either reset line causes the line to return to zero as shown in Figure 4. Crossing the upper reset line would be designated as a 'cause for concern indicating internal review' and is covered in greater detail in Section 4.

Figure 4 - Example of a reset on the upper (blue) line



If the lower (brown) line crosses the lower reset line, this indicates that mortality rates are significantly lower than one would expect under normal conditions and would cause the lower line to reset to zero as shown in Figure 5. Although this would not trigger a 'cause for concern', PICANet would recommend a review in order to identify best practice and any statistical issues. This is covered in greater detail in Section 4.

Figure 5 - Example of a reset of the lower (brown) line



Although the RSPRT plot is derived using statistical techniques it is up to individual units to interpret what is happening clinically. The plot gives an indication from the data derived from PIM3 and PICU outcome about whether you are seeing expected or 'out of control' performance, but this could just be a simple reflection of what you already know is happening.

4 RSPRT outcomes and PICANet quarterly emails

Units are able to view their RSPRT plot at any point via PICANet Web, and it is recommended that they do this on a regular basis to pre-empt any triggers and allow sufficient time to investigate any issues (see case study 1 in Appendix 1). PICANet will also email units in each quarter (usually January, April, July & October), informing each unit of their current status. The email will designate a unit as having:

- Satisfactory performance
- Cause for close monitoring
- Cause for concern indicating internal review (higher mortality than expected)
- Plot reset requiring data review (lower mortality than expected)
- Unable to assess due to lack of data

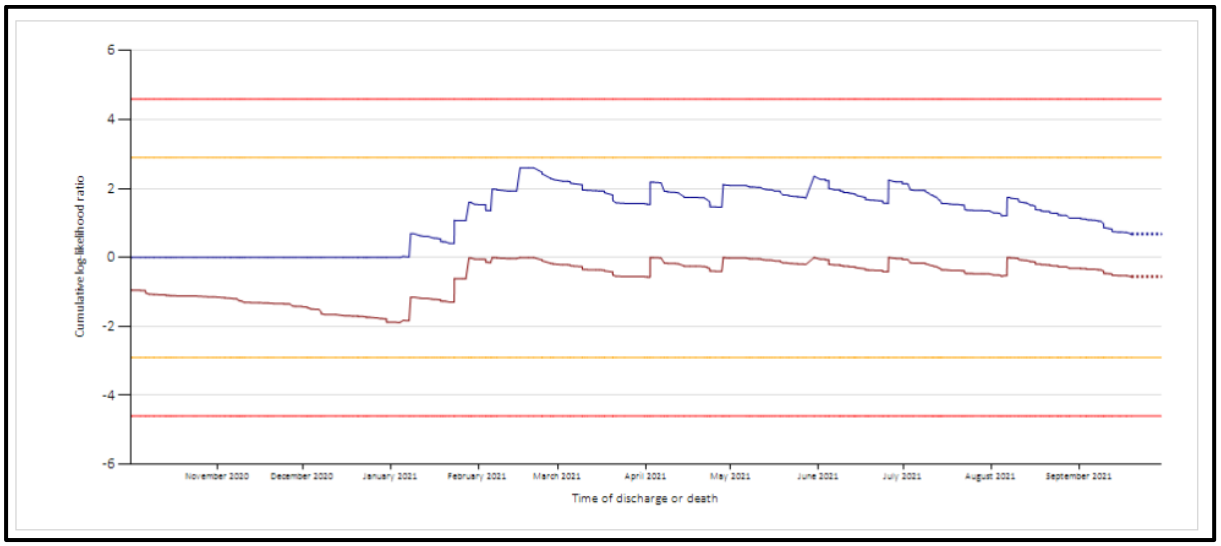
The outcomes from the RSPRT are set out below. Units should expect to be designated as belonging to one of these categories during each quarter and take action as appropriate.

1. Satisfactory performance

When does this occur?

Performance is said to be satisfactory when the plot remains between the two yellow threshold lines in the period of interest OR has not crossed either yellow threshold line for more than three consecutive months.

Figure 6 - Example of RSPRT plot showing satisfactory performance



What does this mean?

This indicates that current performance appears to be in line with expected natural variation.

What action is required by the PICU?

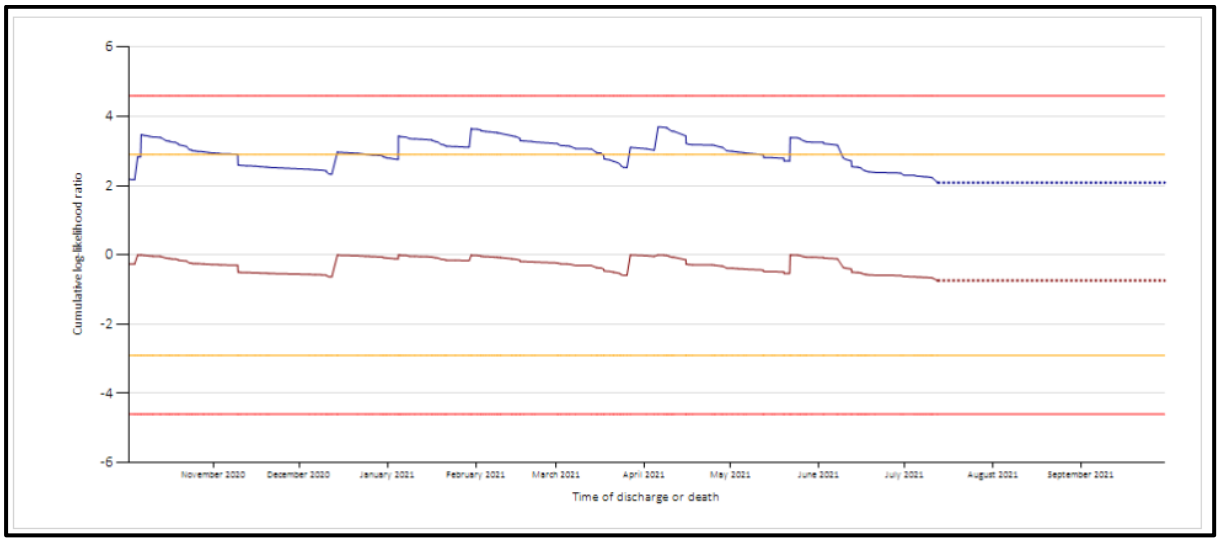
None – continue to monitor at quarterly intervals as a minimum.

2. Cause for close monitoring

When does this occur?

Either the upper (blue) line or lower (brown) line remains between orange and red lines (in either 'warning zone' as indicated on Figure 3) for three or more consecutive months. On the upper section of the chart this indicates an increased log-likelihood of the log-odds of mortality doubling (shown in Figure 7), and on the lower section of the chart it is correspondingly related to mortality halving.

Figure 7 - Example of RSPRT plot showing cause for close monitoring for the upper (blue) line



What does this mean?

This indicates that performance is temporarily outside what would be expected after taking into account natural variation and how sick children are at admission. This could be indicating higher mortality than expected or lower mortality.

What action is required by the PICU?

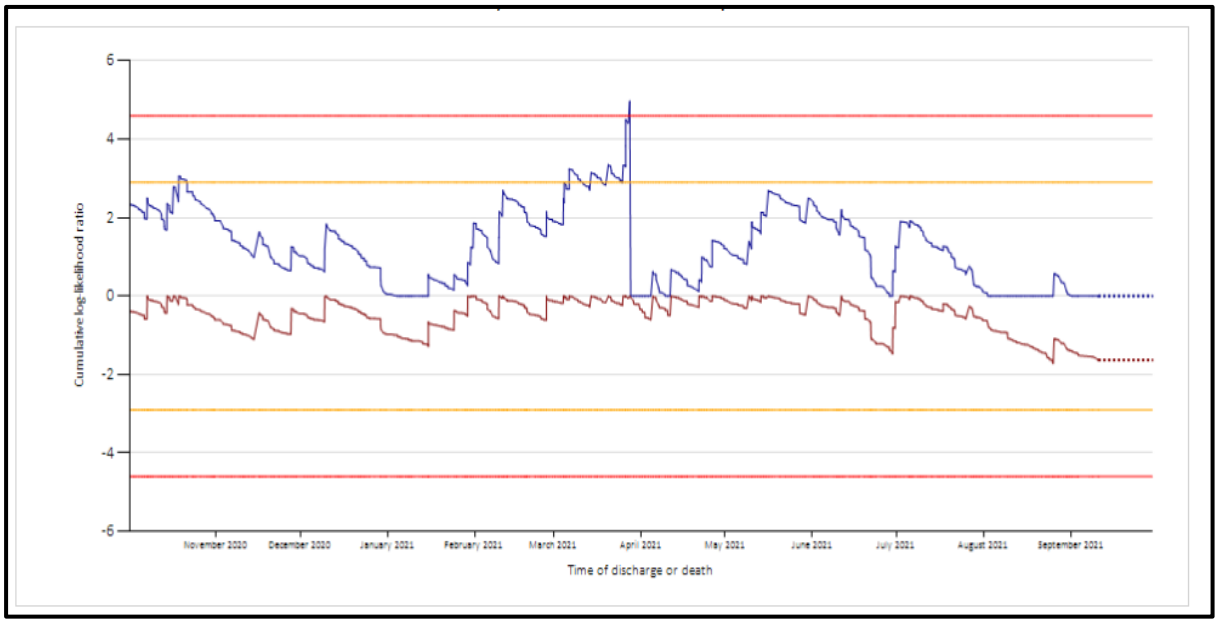
It is recommended that performance is closely monitored on a monthly basis for a few months by downloading the live RSPRT plots from PICANet Web. It will be important to ensure that mortality rates on the top section of the chart decline below the orange line or that reasons for being in the 'warning zone' are understood.

3. Cause for concern indicating internal review (higher mortality rate than expected)

When does this occur?

Performance is said to be cause for concern requiring internal investigation if the RSPRT plot resets due to crossing the upper (higher mortality than expected) red line (example shown in Figure 8).

Figure 8. Example of RSPRT plot indicating cause for concern (higher mortality than expected)



What does this mean?

If the higher limit has been crossed, this indicates that the odds of mortality doubling are higher than would be expected after taking into account natural variation and how sick children are at admission.

What action is required by the PICU?

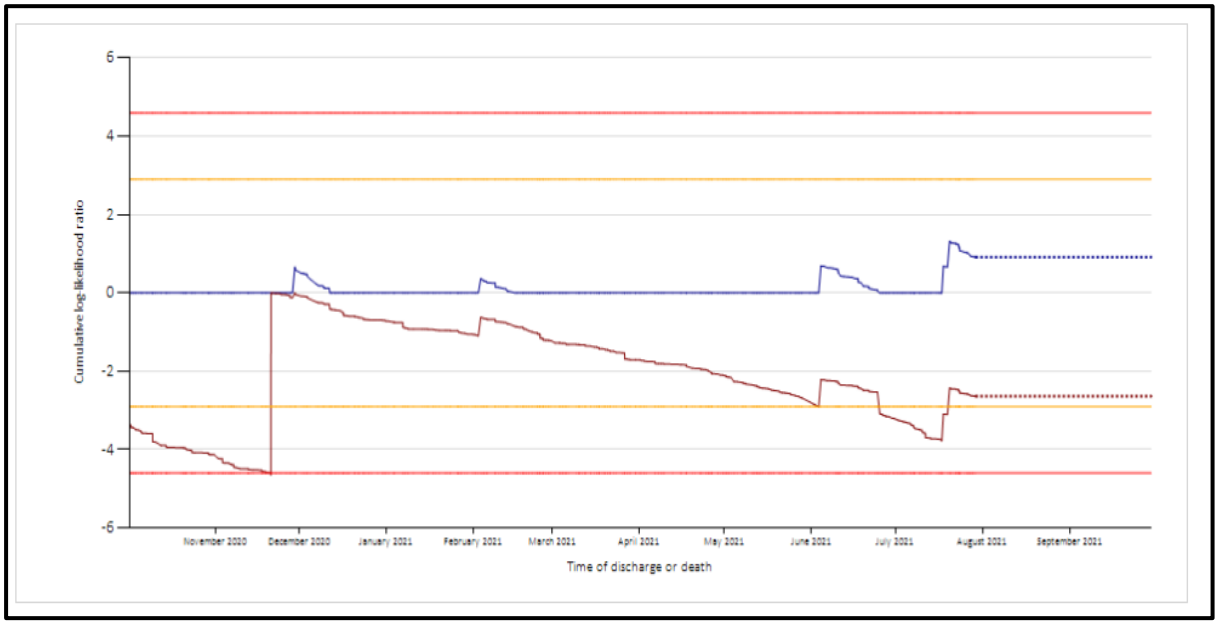
PICANet require units to investigate the cause of the reset. Distinct from the process detailed in PICANet's outlier policy, this review should be internal to units and for the purpose of reacting in a timely fashion to unexpected signals from the RSPRT plot. The review should aim to understand the reason for the reset and identify if there were any modifiable factors in the child's care that may have contributed to vulnerability, ill health or death. (See Table 1 for step-by-step guidance for an internal review).

4. Plot reset requiring data review (lower mortality than expected)

When does this occur?

Performance is said to require a data review when the RSPRT plot resets due to crossing the lower (lower mortality than expected) red line (example shown in Figure 9).

Figure 9. Plot reset requiring internal review (lower mortality than expected)



What does this mean?

If the lower limit has been crossed then this indicates that the odds of mortality doubling are lower than what would be expected taking into account natural variation.

What action is required by the PICU?

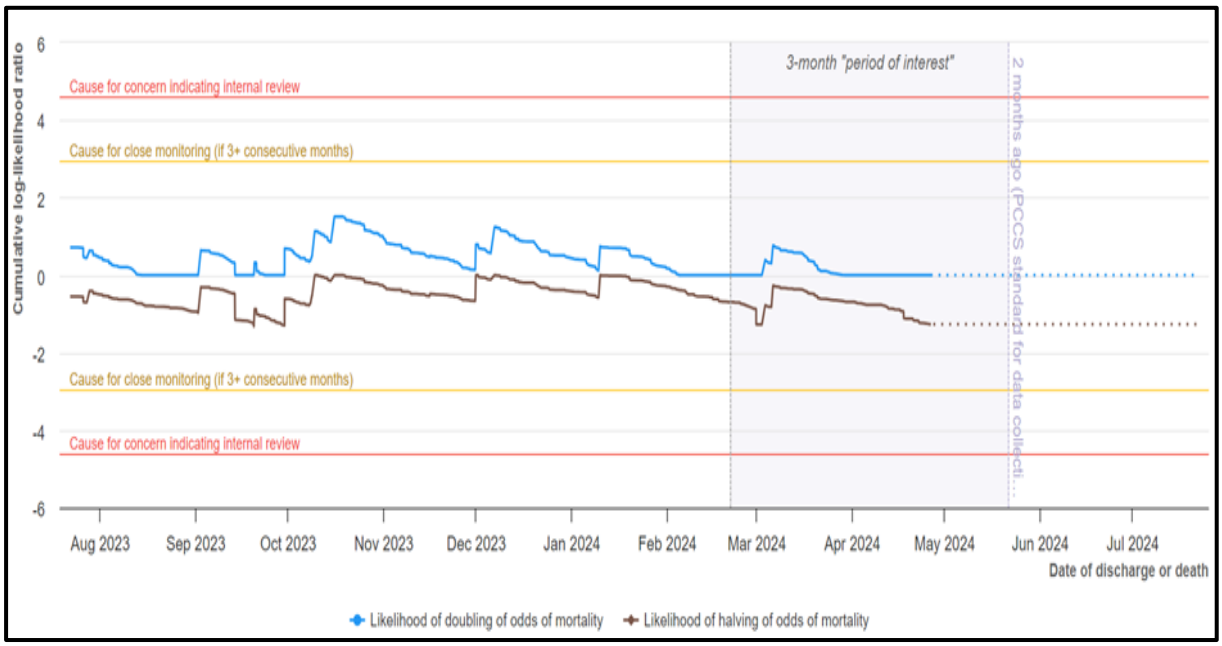
Despite indicating a lower mortality, PICANet require units to review a reset on the lower line to understand the reasons behind it. This may relate to issues with the data or be an example of good clinical practice that may be shared. (See Table 2 for step-by-step guidance for a data review). Feedback from the data review may be added (with permission) to the PICANet QI page: https://www.picanet.org.uk/quality-improvement-resources/.

5. Unable to assess

When does this occur?

Performance cannot be assessed within the current RSPRT chart due to the unit not submitting enough data to cover the complete quarter (see Figure 9)

Figure 9 Unable to assess RSPRT plot



What does this mean?

PICANet are unable to report on the RSPRT chart findings as it is incomplete due to a lack of submission of data or poor-quality data submission.

What action is required by the PICU?

PICANet will ask the unit to prioritise data entry/completion for the quarter pertaining to the RSPRT plot. We will then reassess the unit when the data has been entered and PICANet will be informed that this has been completed.

Table 1 – Guidance for units required to undertake an internal review (higher mortality than expected)

<table>
<tr><th>Stage</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td colspan="2">Receipt of quarterly RSPRT plot email from PICANet indicating a cause for concern requiring internal review</td></tr>
<tr><td>2</td><td colspan="2">Following receipt of the email the Lead Clinician or PICANet lead should start the internal review taking into account the steps outlined in this table to:
Confirm the accuracy and completeness of data submitted to PICANet Web
Identify any policies or changes in practice which might have led to the resetting of a threshold</td></tr>
<tr><td rowspan="2">3</td><td colspan="2">Step 3.1: Gather your team; including analysts/IT support/clinicians to support your investigation.

Step 3.2: Choose an appropriate timeline to review based on the chart with the reset; for example:
3 months prior to reset
start of the rise of the line
Step 3.3: Review the PIM3 variables on the cohort of children selected from which the risk adjustment is based:
Compare the PIM3 value on PICANet Web to the PIM3 values in the child’s notes - consider the following question and comments</td></tr>
<tr><td>Question: Are the PIM variables correct?</td><td>is the submission/import a true reflection of those observations made within the first face-to-face contact with a specialist paediatric doctor up to one hour after admission?
check admission times on both paper and electronic records – are there any values missing that should have been available within the first hour?
have the variables been obtained from the transport unit if the child has been retrieved?</td></tr>
</table>

<table>
<tr><td>Stage</td><td colspan="2">Action</td></tr>
<tr><td></td><td></td><td>• Do the data on PICANet Web accurately reflect the information in the child's notes?</td></tr>
<tr><td></td><td colspan="2">Step 3.4: Look for common themes within this cohort of children – for example:
• are they on an end-of-life pathway?
• do they have a large number of co-morbidities?
• are they all post-operative – did they have a new surgeon, theatre technique?
• are they undergoing new treatments/procedures?
• the nature of referrals to the coroner.
Note that the above are prompts and should not be considered as an exhaustive list.</td></tr>
<tr><td></td><td colspan="2">Step 3.5: Look at the wider clinical picture. For example:
• the wider context of critical incidents reported/serious harm incidents/ mortality and morbidity reviews
• any changes in clinical practice/policies/demands
• consider bed occupancy, staffing, time of year
• delayed discharges, readmissions
• new equipment, new medications
Again, the above list should be considered non-exhaustive as prompts for the unit to explore their own wider clinical picture.</td></tr>
<tr><td></td><td colspan="2">Step 3.6: Consider changes to demands in the use of the unit in response to wider or national pressures, for example:
• taking more complex cases than usual
• taking on more end-of-life care than usual
• more grown-up congenital heart demands
• readmissions due to demands on Level 2/ward facilities</td></tr>
<tr><td>4</td><td colspan="2">Make any changes and re-run the RSPRT plot
• If the RSPRT plot resets to a 'satisfactory' or 'cause for close monitoring' record a summary of the findings incorporating 'lessons learnt'</td></tr>
</table>

Stage	Action
	• If the RSPRT plot still shows a cause for concern requiring internal review' then PICANet will carry out their own **internal review** which will focus on a review of provider data quality and completeness for relevant fields (including PIM variables and unit discharge status)
5	Lead clinician/PICANet Lead to finalise review with PICANet by: • Giving details of the data checks undertaken, whether inaccuracies or missing data were found and any action taken to address data quality issues. • Confirming that the resubmitted data was complete, accurate, and validated (specifically in relation to the PIM3 variable and the discharge status). • Outlining possible explanations for the RSPRT status. • Passing on any other information deemed relevant such as lessons learnt/strategies to be employed in the future that could be shared anonymously with the wider PIC community

Table 2. Guidance for units required to undertake a data review (lower mortality than expected).

<table>
<tr><th>Stage</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td colspan="2">Following receipt of this email the Lead Clinician or PICANet lead should start the data review taking into account the steps outlined in this table to:
Confirm the accuracy and completeness of data submitted to PICANet Web
Identify any policies or changes in practice which might have led to the resetting at a threshold</td></tr>
<tr><td rowspan="3">2</td><td colspan="2">Step 2.1: Choose an appropriate timeline to review based on the chart with the reset;
For example:
3 months prior to reset
start of the descent of the line
Step 2.2: Review the PIM3 variables on the cohort of children selected from which the risk adjustment is based:
Compare the PIM3 value on PICANet Web to the PIM3 values in the child’s notes - consider the following questions and comments</td></tr>
<tr><td>Question: Are the PIM variables correct?</td><td>Is the submission/import a true reflection of those observations made within the first face-to-face contact with a specialist paediatric doctor up to one hour after admission?
Check admission times on both paper and electronic records – are there any values missing that should have been available within the first hour?
Have the variables been obtained from the transport unit if the child has been retrieved?
Do the data on PICANet Web accurately reflect the information in the child’s notes?</td></tr>
<tr><td colspan="2">Step 2.3: Look at the wider clinical picture;
For example,
Have there been any recent quality improvement initiatives introduced which might be relevant for the period reviewed
Have there been any changes in clinical practice/policies/demands</td></tr>
</table>

	• Consider bed occupancy, staffing, time of year • New equipment, new medications • Consider a new palliative care pathway or critical care outreach team. Again, the above list should be considered non-exhaustive as prompts for the unit to explore their own wider clinical picture.
	Step 2.4: Consider changes in the use of the unit in response to the wider local environment; For example, • More discharges to HDU to increase capacity within the step-down unit • More cases being reviewed by a critical care outreach team, reducing burden on the PICU
3	Make any changes and re-run the RSPRT plot • If the RSPRT plot no longer resets, record a summary of the changes made to the data • If the RSPRT plot still shows the plot resetting due to crossing the lower red line then make your report to PICANet as set out below
4	Lead clinician/PICANet Lead to finalise review with PICANet by: • Giving details of the data checks undertaken, whether inaccuracies or missing data were found and any action taken to address data quality issues. • Confirming that the resubmitted data was complete, accurate, and validated (specifically in relation to the PIM3 variables and the discharge status). • Updating on the status of the RSPRT plot if this has changed. • Outlining possible explanations for the RSPRT status. • Passing on any other information deemed relevant such as good practice or quality improvement initiatives which may have had a positive effect.

Appendix 1 – Case study of unit response to RSPRT reset

Paediatric Intensive Care Audit Network (PICANet) Quarterly RSPRT plot - Cause for concern requiring further internal investigation

We [the unit] were notified by PICANet in October 2019 that three risk-adjusted resetting sequential probability ratio test (RSPRT) reset points had occurred that suggested a higher PICU mortality rate than expected between the period 01/07/2018 to 30/06/2019.

PICANet advise that the RSPRT plot is to be used by teams when there are resets to identify any possible cause, which includes reviewing data and cases to identify any issues with quality of care provided in ICU.

How we responded:

A Consultant in Paediatric Intensive Care, a Deputy Chief of Service, and the Trust Clinical Audit Manager led the response to this.

The following steps were taken:

- At an early stage we were able to seek guidance from PICANet on the steps we should take in response to the reset. We were not using the RSPRT and were not familiar with its application and methodology, and of the quarterly exception reporting process. We are grateful for the support that was provided to confirm the steps that we should take in responding to the reset points.
- We then understood the requirement to use the resets to identify any possible reason for the resets, which included reviewing data and cases to identify any issues with the quality of care provided in ICU.
- Our requirement, and plan to do this, was communicated to relevant ICU staff, Medical Director and Head of Quality and Safety, and to our internal patient safety committee.

In December 2019 we had completed our review and reported our findings to our internal patient safety committee.

PICANet recommendation in response to a reset	**What we did**
"We urgently recommend that your unit checks the data submitted to PICANet Web."	Cases around the reset points were promptly reviewed by a Consultant in Paediatric Intensive Care. This highlighted that there were data missing from the PICANET submission. An omission of data can have a negative impact on the accuracy of the PIM3 calculation. The PIM3 score was then recalculated following identification of missing data. This highlighted that there were two reset points, compared to the three initially reported.
"If, following data checks, your revised RSPRT plot still shows cause for concern, then PICANet recommend an internal review of your mortality cases"	A Consultant in Paediatric Intensive Care undertook a review of cases in the reset period involving • Identifying any commonality based upon the child's diagnosis • Nature of referrals to HM Coroner • Assessment of trends around clinical incident reporting • Reviewing the outcomes of cases in the reset period which were reviewed by the hospital's mortality review group. The hospital mortality review group was a group of clinicians who reviewed all inpatient deaths in the organisation to identify whether there were modifiable factors in the child's care which may have contributed to vulnerability, ill health or death. This was the main mechanism, in addition to speciality led morbidity and mortality meetings, for reviewing deaths internally, prior to the statutory implementation of Child Death Review Meetings in October 2019.
"*Closely monitor the risk-adjusted resetting*	The RSPRT was added as item to be reviewed at the ICU morbidity and mortality (M&M) meetings.

sequential probability ratio test (RSPRT) plot over the following months"	

Our conclusion

Deaths in the 'reset' period were reviewed to try and identify any cause for the resets. A trigger could be due to a run of very sick patients dying over the course of a month but could also be due to a few patients with low risk of mortality dying. A review of the cases in the reset period demonstrated a cohort with considerable comorbidities which were not necessarily reflected in the PIM3 scoring. This included patients who died post Bone Marrow Transplant (BMT), where the BMT did not occur during that admission. This was fed back to PICANet to review through the PICANet Clinical Advisory Group.

What we changed as a result of this process

- Actions were quickly put in place to improve the accuracy of the PIM3 data recorded on admission. This included
    - The Information Team attending the ICU on the first working day following a new admission to review the information with the clinical team that should be entered as part of the PIM3 dataset.
    - A designated consultant was identified for each unit to provide oversight and offer support to the Heart and Lung Information Team where necessary.
- The RSPRT plot was added as a recurring item to be reviewed at ICU morbidity and mortality (M&M) meetings. This has helped us to ensure that trends can be explored in real time ahead of external notification.