

Reporting guidance for ICUs to explore their Standardised Mortality Ratio (SMR)

Introduction/Preamble

The ANZICS Outlier Management Program (OMP) was introduced in 2007, and over the subsequent 15 years has identified more than 50 potential outliers, all of which have been adult intensive care units (ICUs). While there have been no potential outliers identified from contributing paediatric intensive care units (PICUs), the approach developed for use with adult ICUs applies equally to PICUs. The OMP is thought to have produced savings to the Australian health economy of approximately \$36 million and contributed to a 35% fall in the SMR for adult ICUs¹. The program is broadly based on quality control theory described by Shewhart in the early parts of the 20th Century when trying to reduce variation in outcome. Variation comes in two forms (as described by Shewhart); common cause or natural variation and special cause variation. Common cause variation is inherent in any system and is caused by factors that consistently affect the process over time. This can largely be thought of as expected variation due to chance. Special cause variation, by contrast, arises due to specific, often identifiable sources. It is often unpredictable and requires an active search for its root cause(s).

The basis for ANZICS outlier identification is the funnel plot – a graphical tool used to detect variation across ICUs while accounting for the number of admissions, or sample size (figure 1). The funnel plot helps identify whether observed mortality differs substantially from expected (predicted) risk-adjusted mortality. For the ANZICS outlier program, risk adjustment is undertaken using the Australian and New Zealand Risk of Death (ANZROD) scoring system for adult units and the third iteration of the Paediatric Index of Mortality (PIM3) scoring system for PICUs – both of which are highly discriminatory locally derived scores which are re-calibrated on a regular basis. The standardised mortality ratio (SMR) is derived from the number of observed deaths divided by the number of predicted deaths (the numerical sum of individual risk of death derived using the relevant risk adjustment model). Reports are produced quarterly sampling the previous 12 months' admissions and provided to contributing sites. An SMR of one implies that the number of observed deaths equals the number of predicted deaths, an SMR greater than one implies more deaths than expected, and an SMR of less than one implies fewer deaths than expected.

In adult ICUs, ANZROD is preferred over other models of risk prediction because it better accounts for case-mix differences in Australian/Aotearoa New Zealand ICUs, making mortality comparisons more accurate. ANZROD uses a combination of patient-related variables (age, APACHE chronic diseases, presence of treatment limitation orders), diagnostic (admission source, ICU admission

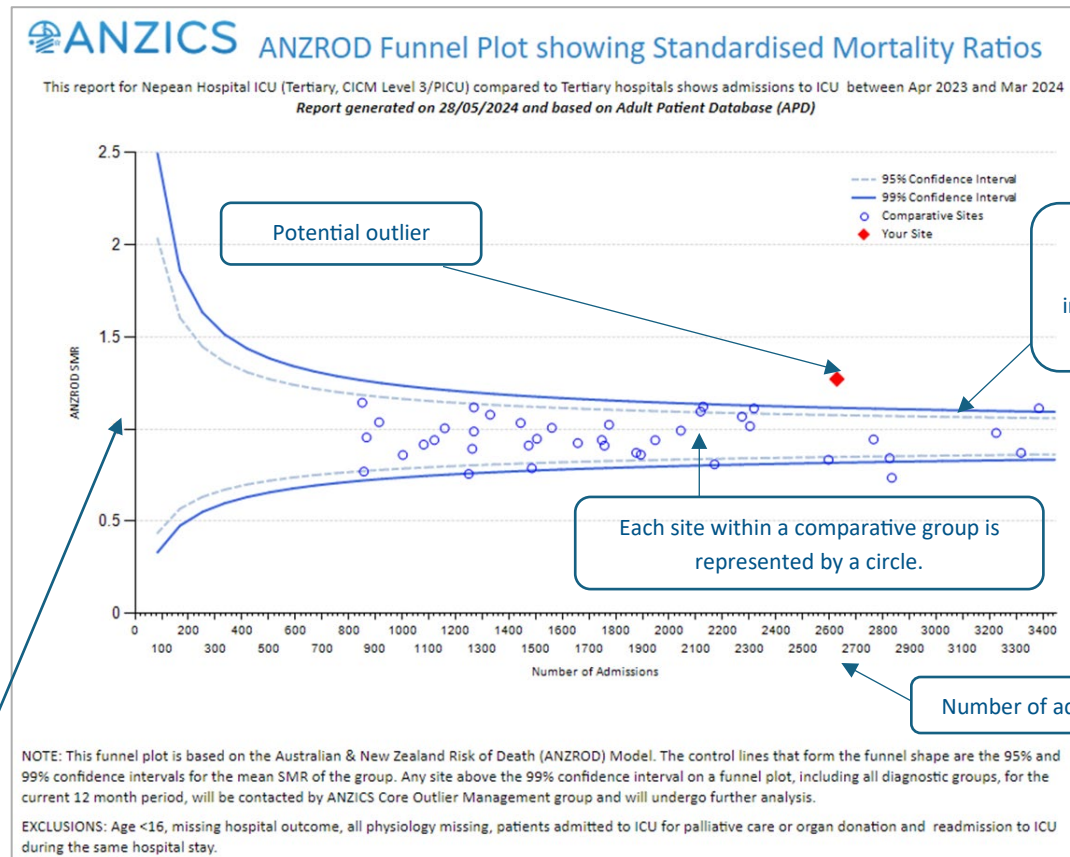
diagnosis, post-operative status) and physiological variables (including the need for mechanical ventilation in the first 24 hours) with a separate prediction equation for each of the broad APACHE III/IV diagnostic categories. Admissions excluded for ANZROD calculations are patients aged less than 16, patients admitted for palliative care or organ donation, and patients in whom outcome data or all physiology data is missing.

The Paediatric Index of Mortality 3 (PIM3) was built using data across Paediatric ICUs in four countries, i.e. Australia, New Zealand, the United Kingdom and Ireland. PIM3 uses a combination of diagnostic characteristics and physiological variables at admission in its model to calculate a risk of death in ICU.

The outer control limits which give the plot its characteristic funnel shape are derived from the confidence intervals of the SMR, and, for the ANZICS funnel plots the dotted line represents the 95% confidence interval and the solid line the 99% confidence interval. ICUs that fall within the funnel plot have variation that is explained by statistical chance (Shewhart's common cause variation), while ICUs who fall outside the funnel plot suggest special cause variation which warrants further investigation.

Individual ICUs are compared to their peer hospitals, broadly grouped by the type of hospital in which the ICU is located, which in turn has an impact on the case-mix of the unit. Groupings used by ANZICS for adult ICUs are tertiary, metropolitan, regional/rural and private. For PICUs, given the much smaller number of dedicated units across Australia and Aotearoa New Zealand, comparison is taken across all units. Subgrouping may occur if appropriate for PICUs in tertiary children's hospital, PICUs in general hospitals, and mixed ICUs who admit a combination of adult and paediatric patients.

Figure 1: ANZROD Funnel Plot



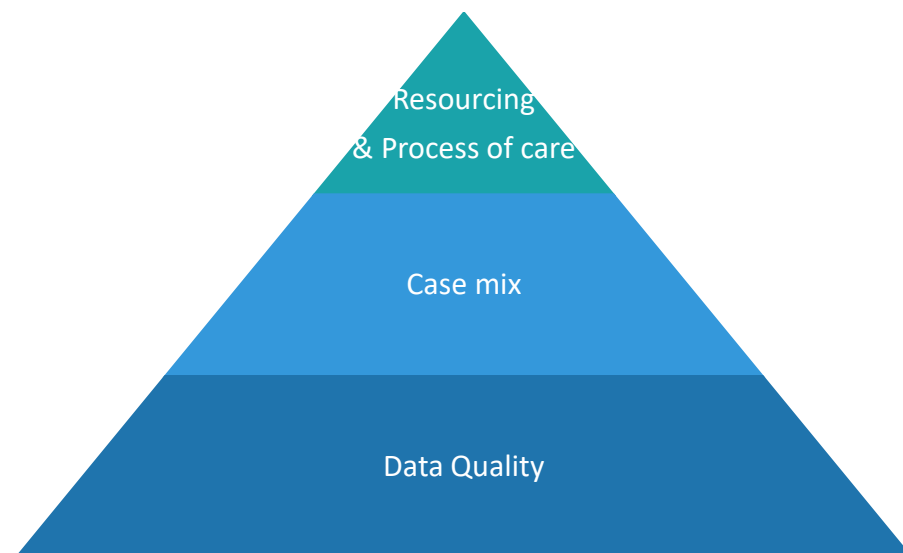
SMR = observed deaths / predicted deaths

The ANZICS outlier program recognises two stages. An “alert” phase when an ICU falls between the 95% and 99% confidence intervals, and an “alarm” phase when an ICU falls outside the 99% confidence interval. The alert phase triggers an email to the ICU director, while the alarm phase triggers a formal outlier investigation as per the [ANZICS outlier policy](#). The ICU forecast project is a unique proof of concept trial currently underway which hopes to provide individual ICUs with a prediction of the risk of becoming an outlier ICU in upcoming reporting periods (in much the same way that the Bureau of Meteorology makes predictions about the likelihood of rain).

A formal outlier report is a highly detailed analysis of the data drawing on individual patient level information drawn from the Adult Patient Database (APD) for adult units, or the Australian and New Zealand Paediatric Intensive Care Registry (ANZPICR) for paediatric units, combined with data from the annual Critical Care Resources (CCR) survey and the Critical Health Resources Information System (CHRIS) to inform insights into possible contributors to special cause variation. The reports are overseen and reviewed by the Outlier Working Group for adult ICUs or the ANZPICR Clinical Advisory Committee for paediatric ICUs.

Reports contain three sections – a single page executive summary designed for high level insights, a brief narrative review of key points, and a detailed analysis of the datasets which may assist ICUs identify causes for special variation. The analysis is based on the pyramid model for detecting credible causes for high mortality (figure 2). This model suggests the most likely reasons for special cause variation, which, in order of decreasing likelihood are data quality issues, patient case-mix, structures and resources, processes of care and finally individual clinician behaviour. ANZICS reports do not comment individual clinicians. It is infrequent that there is a single element that is responsible for special cause variation.

Figure 2: Pyramid model of investigation to find credible cause for high mortality of patients modelled on **BMJ** 2004;324:1474-7. (<https://pmc.ncbi.nlm.nih.gov/articles/PMC428518/>)

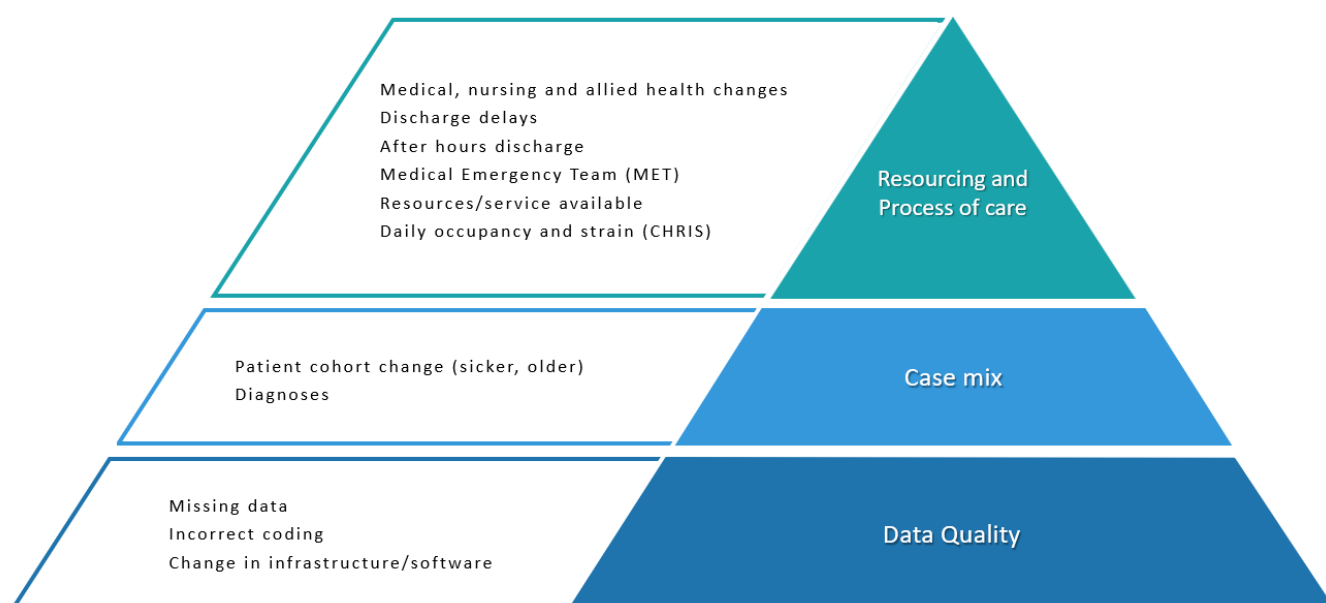


ICUs which have been identified as outliers take a median of 3 reporting periods of 3 months each to return to the funnel plot. As a result, outlier reports are only undertaken annually.

ICUs can leverage the [CORE Portal](#) to access a number of reports that can inform each unit of their activity and SMR, remembering to run the report with the appropriate hospital comparison group. The next section contains specifics of the detailed analysis the ANZICS team undertake.

CORE Portal Reports

All reports described here are available through the CORE Portal. [Click here](#) to log. If you do not have access, please contact your site admin to add you as a Reporting access via User Management Tool. If you do not know your Site Administrator, please contact CORE Team via core.registries@anzics.org



1. Data Quality

a) Data Quality Report

- Missing data is important as any values which are missing are treated as normal for the purposes of risk adjustment and can therefore artificially elevate the SMR by reducing the predicted risk of death. The data quality section provides details of missingness data for biochemical, physiological and diagnostic variables compared to peer hospitals for a selected time period. Recommend reviewing data quality in the time-period immediately preceding the identification of potential outlier status.

b) Outcomes and Severity Report

- Provides comparison of severity of illness scores, observed mortality, predicted mortality and other outcomes like readmissions to ICU, discharge destinations etc. General interpretations as follows:

Observation	Possible conclusion	Next steps
-------------	---------------------	------------

Comparable severity of illness, but high ICU/Hospital mortality and SMR	-Data quality -High mortality due to inclusion of organ donation/palliative care	- Maybe be due to missing data, check data quality report -Check coding for Treatment Goals for admission variable
Comparable severity of illness and ICU mortality, but high Hospital mortality and SMR	- Inadequate mechanisms for detection of and responding to patient deterioration on ward -Premature discharges	-Check high rate of readmission. -Check resource issues in the CCR data. -No MET teams?
Comparable severity of illness and ICU/Hospital mortality, but high SMR	-Predicted mortality is lower due to high missing data artificially elevating SMR	-Check data quality report. -Check EWMA for downward trend in control lines. -Was there a change in data collector/ CIS system at the time?
High severity of illness and ICU/hospital mortality, and high SMR	-Case mix or demography changes	-Check which cohort shows high numbers and SMR.

c) Activity Report

- Provides comparison of ICU patient demographics and activity to identify the differences.

Observation	Possible conclusion	Next steps
High ventilated patients	-High acuity patients	-Check if this contributes to high SMR on funnel
Different top 5 diagnosis	-Case mix differences	-Check which cohort shows high numbers and SMR
Different distribution for ICU admission source	-Case mix differences	-Check if this contributes to high SMR on funnel
Differences in safety indicators	-ICU resource issue	-Check CCR Reports for differences
High discharge delay (bed block)	-Less resources on hospital ward	-Internal audit to see hospital process issues
High after hours discharges	-Premature discharge, hospital wide process issue	-Internal audit to see hospital process issues

2. Case Mix

Case mix analysis focusses on two broad questions:

1. Is there a subgroup in this ICU which truly has a higher mortality than similar patients in other hospitals? This is to say a true increase in risk adjusted mortality.
2. Is there are subgroup in this ICU who have the same mortality as similar patients in other ICUs but the risk prediction model underpredicts mortality estimates? This is to say an issue of inaccurate mortality prediction.

To answer these questions several analyses are undertaken.

- a) ANZROD (or PIM3) adjusted funnel plot by the various Ventilation Types (Non ventilated, Ventilated, Ventilated excluding Cardiac surgery)
- b) ANZROD (or PIM3) adjusted funnel plot by various Diagnostic Groups (All Diagnoses, Non-operative/medical, Sepsis and other infective diagnoses, cardiac surgery diagnoses, trauma/burns/neuro diagnoses, post-operative/surgery, elective surgery)
- c) ANZROD (or PIM3) adjusted funnel plot by various ICU Admissions Sources (Accident & Emergency, OT/Recovery, ward)

If your Hospital is above 99% CI for any of these funnel plots, run the same report for two prior reporting periods to see which shows a significant change.

- d) ANZROD (or PIM3) adjusted EWMA Chart – to see any peak mortality times.

A line moving up indicates an increase in mortality, while a line moving down indicates a decrease. The observed mortality should fall between the upper and lower predicted mortality control limits, meaning that the unit has been performing according to the ANZROD prediction for mortality.

- e) Efficiency Plot

An ICU with a Risk Adjusted Length of Stay Ratio (RALOSR) who's lower 95% confidence interval is greater than one, has a longer overall ICU length of stay than would be expected from the baseline severity of illness of their patients. If an ICU finds their RALOSR is high, this may be due to either large numbers of patients where the length of stay predictions have underestimated the true length of stay (e.g. those who require renal replacement therapy), or large numbers of patients who have accurate predictions of length of stay but really spent longer than expected in the ICU (e.g. patients with 'exit block' who were ready for discharge but transfer to the ward from ICU was delayed). The ANZICS 'ICU Efficiency Plot' is a modification of The Rapoport-Teres plot, which graphs the SMR as an indicator of clinical

performance, against the RALOSR as a marker of resource use. ICUs in the lower left quadrant which have a low SMR and low RALOSR represent the most 'efficient' ICUs.

f) After Hours Caterpillar

The plot shows the proportion of alive patients discharged after-hours (between 6pm and 6am) from ICU. The error bars represent the 95% confidence intervals for each site. This plot shows unadjusted after-hours discharge rates which have been calculated without accounting for severity of illness or propensity to be discharged after-hours from ICU. Readmissions during the same hospital stay, patients who do not survive their first admission to ICU and patients discharged to another ICU or hospital are excluded from this analysis.

g) Readmission Funnel

The funnel plot shows the proportion of patients who are readmitted to ICU within the same hospital episode, using unadjusted readmission rates which have been calculated without accounting for severity of illness or propensity to be readmitted to ICU. The readmission rate of each unit within a hospital classification is shown with control lines, taking the shape of a funnel, produced by the 95% and 99% confidence intervals around the mean readmission rate of the group. Only patients who survive their first admission to ICU are included in this analysis, and patients with multiple readmissions are only counted once.

3. Resourcing and Processes of Care (using Critical Care Resources (CCR) data and Critical Health Resourcing Information System (CHRIS))

This section draws on data from the Critical Care Resources (CCR) survey and data drawn from the Critical Health Resourcing Information System (CHRIS). The Critical Care Resources data is a self-reported survey completed by the site annually for each financial year.

- a) Annual Summary Report (reports APD and CCR data)
- b) CCR – Comparative Report
- c) CCR – Allied Health Report
- d) CCR – Safety & Quality Activities
- e) CCR - Research Infrastructure
- f) CHRIS ICU Activity reports

Click [here](#) to access Critical Health Resource Information System (CHRIS), if you do not have access contact support@chris.health.gov.au. CHRIS is a real time, web-based bed occupancy reporting tool used by health services nationally. It provides a national, statewide, and, hospital level view of critical care capacity, and available resources, based on regular hospital data input.

If further information is required a Data Request can be submitted for a basic Outlier Report to be generated by ANZICS. Please [click](#) here to obtain a data request form.

References

¹The Australian Commission on Safety and Quality in Health Care. Economic evaluation of clinical quality registries: Final report Sydney: ACSQHC; 2016