NOD Audits Case Complexity Adjustment

Document author

Paul Henry John Donachie

Senior Medical Statistician for the RCOphth NOD

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1 Abbreviations

Abbreviation	Description
AMD	Age-related Macular Degeneration
CI	Confidence Interval
ETDRS	Early Treatment Diabetic Retinopathy Study
EMR	Electronic Medical Record
LogMAR	Logarithm of the Minimum Angle of Resolution
NHS	National Health Service
NOD	National Ophthalmology Database
PCR	Posterior capsule rupture
RCOphth	The Royal College of Ophthalmologists
VA	Visual Acuity

2 Acknowledgements

The National Ophthalmology Database Audit (NOD) is conducted under the auspices of The Royal College of Ophthalmologists (RCOphth) and conducts the National Cataract Audit focusing on publicly funded cataract surgery and the UK AMD Audit, focussing on publicly funded treated for neovascular age-related macular degeneration (AMD).

We acknowledge the support of the hospitals that are participating in the RCOphth NOD and thank our medical and non-medical colleagues for the considerable time and effort devoted to data collection. All participating centres are listed on the RCOphth NOD website (www.nodaudit.org.uk).

We acknowledge with thanks the contribution of Professor John Sparrow who provided diligent clinical and academic oversight and leadership of the NOD over many years to bring it to its current stature. It is with gratitude that we remember our friend and colleague Robert Johnston, who sadly died in September 2016. Without his inspirational vision, determination and career long commitment to quality improvement in ophthalmology this work would not have been possible.

3 Introduction

The Royal College of Ophthalmologists (RCOphth) is the governing authority for the National Ophthalmology Database Audit (NOD) which conducts the UK Age-related Macular Degeneration (AMD) Audit and the National Cataract Audit. The audits are open to all providers of National Health Service (NHS) and privately funded AMD treatment and cataract surgery in England, Scotland, Northern Ireland, Wales and the Channel Islands. The data is collected as part of routine clinical care on electronic medical record (EMR) systems or in-house data collection systems and the analysis is performed by the RCOphth NOD Audit statisticians based in Cheltenham General Hospital.

Case-complexity adjustment is necessary for fair comparisons between centres administering AMD treatment and between surgeons and centres performing cataract surgery, and for use with outlier detection. If case complexity adjustment was not performed, then reported results could be miss interpreted for centres with resident doctors when compared to centres with only consultants, and for surgeons performing more complicated cataract operations when compared to surgeons who perform less complicated operations. For AMD, case complexity adjustment helps with comparing centres results due to the varying treatment schedules patients can follow for AMD treatment. It is worth noting that, for cataract, there are different grading schemes for case complexity which are used within different home nations for different purposes, such as for defining the tariff paid by the NHS in England for providers working under payments by results. Those grading schemes are based on assumptions about costs to providers, rather than the risk of intraoperative complications or specific outcome measures and are in no way aligned with the NOD risk adjustment process.

The case complexity adjusted results reported in the RCOphth NOD Audits are.

AMD Audit

- 'Good' Visual Acuity (VA) at one year - VA ≥70 ETDRS letters after one year of treatment (positive outcome)
- 'Poor' VA outcome at one year - ≥10 ETDRS letters loss from baseline after one year of treatment (negative outcome)

Cataract Audit

- Posterior Capsule Rupture (PCR) occurring during surgery (negative outcome)
- VA Loss – ≥0.30 LogMAR unit loss after surgery (negative outcome)

4 RCOphth NOD Case Complexity Adjustment method

Case complexity adjustment results in the RCOphth NOD Audits are created using the following method

Adjusted = Comparator * (Observed / Expected)

Where;

- The Comparator value is determined from the supplied data and can be derived differently for different outputs
- The Observed rate is the unadjusted value from the supplied data
- The Expected rate is the excepted value calculated from applying a statistical model to the supplied data

Observed (unadjusted) rate

The Observed (Unadjusted) rate is the number of cases with the outcome divided by the number of treated cases. For example, the number of operations performed in a centre that experienced PCR divided by the total number of operations performed in the centre.

Expected rate

All the RCOphth NOD Audit outcomes with a reported case complexity adjusted results have the expected rate derived from a statistical model, with different statistical models used for each of the outcomes. Each treated eye has a probability of the outcome generated, then for all eyes in the sample the probabilities are summed to produce the expected number of cases for the outcome, and then divided by the number of treated eyes to produce the expected rate, for example if a centre had data for 1,000 operations, they would have 1,000 eyes with a probability of the outcome occurring, these probabilities are summed to produce the expected number of eyes with the outcome in this centre, and divided by 1,000 to produce this centres expected rate.

Full details for the statistical outcome models used by the RCOphth NOD can be found on the RCOphth NOD website. www.nodaudit.org.uk/healthcare-professionals/resources

Comparator values

The Comparator value is derived differently for each outcome, and used for centres results only in the AMD Audit and separately for both centre and surgeon results in the Cataract Audit as follows;

AMD Audit

- The Comparator value is the mean expected probability derived using data for the three most recent NHS years.

Cataract Audit

- For centre results, the Comparator value is the observed (unadjusted) rate for the latest NHS year
- For surgeon results, the Comparator value is the observed (unadjusted) rate for operations performed by non-resident surgeons in the three most recent NHS years

Interpretation

In the Adjusted formula, the Comparator value is a contextual scaling factor applied to the (Observed / Expected) ratio. If this final stage was not included, then Adjusted results would be the ratio of Observed performance to Expected performance and not as intuitive to interpret due to not being on the same scale as the outcome.

Interpretation of Adjusted results being lower or higher than the comparator value is dependent on whether the outcome is negative or positive, Table 1.

Table 1: Adjusted results general interpretation

	Negative outcome	Positive outcome
Adjusted < C	Better than the Comparator value	Worse than the Comparator value
Adjusted = C	The same as the Comparator value	The same as the Comparator value
Adjusted > C	Worse than the Comparator value	Better than the Comparator value

If the Adjusted result is “Better” or “Worse” than the Comparator, then interpretation is in relation to how far away from the Comparator value. There is natural variation between centres and surgeons, and not all of this can be accounted for, thus an Adjusted result X times “worse” than the Comparator value does not necessarily indicate concerning performance. Instead, acceptable ranges for the Adjusted results are required, and these are derived from confidence intervals, produced in relation to the Comparator value and the number of eyes treated.

For the Cataract Audit it is possible that more centres or surgeons have positive results below the Comparator value than would be expected from statistical theory. This is partly due to the scale for Adjusted PCR and VA Loss, where the Comparator value is a small percentage, and as PCR and VA Loss results are influenced by zero inflation, due to centres or surgeons with no cases or PCR or VA Loss in the selected time period. When a centre or surgeon has no cases with the outcome, their Adjusted rates is automatically 0%.

5 Case Complexity Adjustment example

For an example of case complexity adjustment, the following is the process for a centre's PCR result.

The centre's Observed (Unadjusted) PCR rate is calculated by dividing the number of eligible operations that experienced PCR by the number of eligible operations within the relevant time period.

The centre's Expected PCR rate is calculated via first calculating the predicted probability of PCR occurring for all operations in the relevant time period, then summing the probabilities and dividing by the number of eligible operations in the relevant time period.

To adjust for the centre's case complexity (i.e. give credit for how complex or difficult their cases are), this Expected rate is compared against the Observed complication rate by dividing one by the other and then multiplied by the PCR centre level Comparator value to produce the centre's Adjusted PCR rate.

The first two steps are on the operation level:

1: Sum the PCR risk model coefficients (including the constant term) relating to the operation to calculate Y, where Y = ∑relevant model coefficients for each operation plus the constant term.

2: Using the logit transformation convert Y to calculate Z, where Z = exp(Y) / (1 + exp(Y)) and exp = the exponential function.

The next 3 steps are at for the centres eligible sample within the relevant time period.

3: Calculate the Expected PCR rate (E_{PCR}) where $E_{PCR} = \sum Z / n$ and

n = the number of eligible operations performed in the centre

4: Calculate the Observed PCR rate (O_{PCR}) where $O_{PCR} = n_{PCR} / n_{operations}$ and

n_{PCR} = the number of eligible operations performed in the centre that had PCR

$n_{operations}$ = the number of eligible operations performed in the centre

5: Calculate the Adjusted PCR rate (A_{PCR}) where;

A_{PCR} = comparator value multiplied by (O_{PCR} / E_{PCR})

To convert the Adjusted PCR rates to the percentage scale, multiply A_{PCR} by 100.

The same process can be used for all RCOphth NOD case complexity adjusted outcomes.

Once the case complexity adjusted results have been calculated, formal outlier detection in the Cataract Audit can be performed. Currently the AMD Audit does not utilise formal outlier detection.

6 Funnel plots

Funnel plots show the number of operations/eyes on the horizontal axis and the Adjusted result on the vertical axis. Centre/surgeon Adjusted values are plotted with a horizontal line for the Comparator value and confidence intervals (CI). As the number of operations/eyes increases, the width of the CI decreases which is why these graphs are called funnel plots.

The confidence intervals used on the RCOphth NOD Audits funnel plots equate to standards used in most national audits.

- 95% CI is roughly 2 standard deviations from the Comparator value and referred to as the "Alert" level in outlier detection
- 99.8% CI is roughly 3 standard deviations from the Comparator value and referred to as the "Alarm" level in outlier detection

The RCOphth NOD uses the logic transformation when deriving CIs as outcome rates can be close to zero in the Cataract Audit, with the CI deriving process below.

1: The 95% and 99.8% CI are created using the following equation;

$y = x \pm \alpha(se(x))$ where;

$x = \ln (p / (1 - p))$

p = the Comparator value and ln = the natural logarithm

α = the z-values from the normal distribution corresponding to the 95% and 99.8% cut-off points used for the CI, these are 1.96 and 3.01, respectively.

se(x) = the standard error of x which is calculated from the following equation;

$se(x) = \sqrt{(1 / (n(x)(1-x))}$ where n = the number of operations performed

2: By using the logit transformation convert to the appropriate scale to create the values CI where;

CI = exp(y) / (1 + exp(y)) and exp = the exponential function.

To convert the confidence interval values to the percentage scale, multiple CI by 100.

In the Cataract Audit, calculations at the surgeon level are performed differently for each grade at which an individual surgeon has data recorded, i.e. if a surgeon has data for operations they performed as a resident surgeon and as a consultant surgeon, they will have adjustments applicable to the relevant grade at the time that each of their operations was performed. Results for centres include all grades of surgeon (consultant and resident).

Example funnel plots for centres PCR results in the Cataract Audit, and "Good" VA results in the AMD Audit are shown in Figures 1 and 2. In Figure 1, two centres have an adjusted rate of PCR (negative outcome) that is between 2 and 3SD above the comparator value (orange circles). These centres are doing worse than expected. In Figure 2, the proportion of eyes with a good visual acuity outcome (positive outcome), after adjustment for differences in baseline visual acuity, in 5 centres is more than 3SD above the Comparator value. Outcomes in these centres are better than expected.

Figure 1: Cataract Audit year 8 centres Adjusted PCR (Negative outcome).

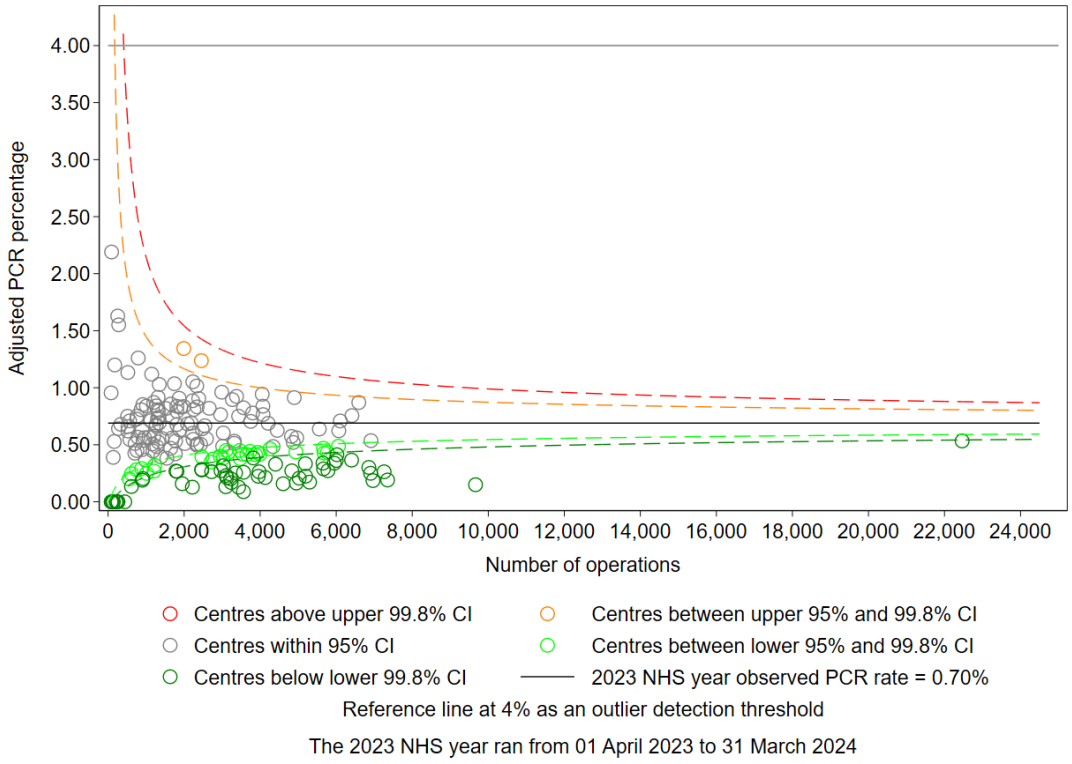

Figure 2: AMD Audit centres year 3 Adjusted "Good" VA results (positive outcome)