# The Royal College of Ophthalmologists' National Ophthalmology Database Audit

## RCOphth NOD Audit National Cataract Audit

## Posterior Capsular Rupture statistical model

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# 1 Abbreviations

| Abbreviation | Description |
|---|---|
| ACD | Anterior Chamber Depth |
| AL | Axial Length |
| CF | Count fingers |
| CQC | Care Quality Commission |
| EMR | Electronic Medical Record |
| GIRFT | Getting It Right First Time Programme |
| HM | Hand movements |
| IOL | Intraocular Lense |
| ISBCS | Immediate Sequential Bilateral Cataract Surgery |
| ISTC | Independent Sector Treatment Centre |
| LogMAR | Logarithm of the Minimum Angle of Resolution |
| NHS | National Health Service |
| NOD | National Ophthalmology Database |
| NPL | No perception of light |
| PCR | Posterior capsule rupture |
| PL | Perception of light |
| RCOphth | The Royal College of Ophthalmologists |
| REF | Reference category for an odds ratio |
| UK | United Kingdom |
| VEGF | Vascular Endothelial Growth Factor |
| VA | Visual Acuity |

## 2 Posterior Capsular Rupture definition

The outcome variable of PCR is defined as in the National Cataract Audit as follows;

PCR is identified from four stages of the cataract pathway; intra-operative complications, operative procedures, post-operative complications, and post-cataract surgery. PCR was considered to have occurred if any of these parts of the cataract operation had PCR indicated.

Intra-operative complications: If any of the following were recorded then PCR was considered to have occurred;

- IOL into the vitreous
- Lens matter in posterior segment
- Nuclear/ epinuclear fragment into vitreous / lens fragments into vitreous
- Nuclear matter in posterior segment
- PC rupture - vitreous loss
- PC rupture – no vitreous loss
- Vitreous loss
- Vitreous to the section at end of surgery
- Zonule rupture – vitreous loss

Operative procedures: If any of the following were performed in combination with the phacoemulsification cataract procedure then PCR was considered to have occurred.

- Sponge and scissors vitrectomy
- Automated anterior vitrectomy
- Scleral fixed IOL
- Fragmatome lensectomy ± IOL
- Removal of lens fragments / nucleus if combined with a pars plana vitrectomy

Post-operative complications/surgery: If any of the following were recorded then PCR was considered to have occurred;

- If any of 'lens matter in posterior segment', 'nuclear matter in posterior segment' 'vitreous to the section' or 'vitreous in the AC' are recorded within 8 weeks of cataract surgery, (including the day of cataract surgery)
- If there is a record of a dropped nucleus operation with 8 weeks of cataract surgery, (including the day of cataract surgery)

# 3 Sample definition

The data submitted to the RCOphth NOD National Cataract Audit used for fitting the updated PCR model comprised cataract operations performed between 01/04/2016 and 31/03/2022 which constitutes 6 completed NHS years.

Eligible for the model fitting sample were National Cataract Audit eligible cataract operations with data for patients' gender and age at surgery, anterior chamber depth (ACD) and preoperative visual acuity (VA). To remove data for potentially abnormal eyes or erroneous data entry, operations were excluded if the recorded ACD was <1.5mm or >4.5mm, or if the recorded axial length (AL) was <18mm. Only data from contributing centres with at least 50 cataract operations satisfying the above were included.

The grade of operating surgeon was categorised as consultant surgeons, career grade non-consultant surgeons (associate specialists, staff grades and trust doctors), more experienced resident surgeons (fellows and specialty trainees / registrars years 3-7), and less experienced resident surgeons (senior house officer, specialty trainees / registrars years 1-2 and foundation doctors).

Preoperative VA was defined as the best recorded distance VA (corrected or uncorrected but not pinhole) that is closest to the date of surgery, including the day of surgery and within 6 months prior to surgery. For numeric calculations, the extreme low vision estimates from the LogMAR chart representing count fingers (CF), hand movements (HM), perception of light (PL) and no perception of light (NPL) are replaced with 2.10, 2.40, 2.70 and 3.00, respectively.
All analyses were performed using STATA 18 (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC).

# 4 PCR risk factor model fitting process

To identify potential risk factors for PCR, a logistic regression model was fitted with cluster adjustment for robust standard errors, where surgeons, their grade and centre they operated in were used to create the clusters. Thus, surgeons with data in different centres have data considered as separate clusters for each centre, and similarly their operative record at different surgeon grades are considered as separate clusters.

The covariates considered as potential risk factors are known before cataract surgery starts. They concern surgeon, patient and ocular factors that could potentially influence the chance of PCR. All candidate covariates were first investigated using Chi-squared tests for categorical covariates, and Student's t-tests with the Welch adjustment for unequal variance for continuous covariates. Categorical covariates indicating association at the 1% level ($p<0.01$) from the univariate analysis were considered in the risk factor modelling, while all continuous covariates were carried through to the risk factor modelling due to clinical relevance and being continuous over a discreet range, which could lead to significant differences over their ranges at the multivariate but not univariate level.

The categorical variables indicating univariate association at the 1% level, plus the continuous covariates and an interaction term for patients' gender and age, were fitted to a multivariate logistic regression model with cluster adjustment for surgeons, their grade and centre the operation was performed in. The final PCR risk factor model was created using backwards selection from the 'full' model to the 'best fitting' model. Covariates were first removed if there was no significance at the 1% level ($p>0.01$), and then any remaining covariates indicating significance between 0.1% and 1% ($p>0.001$ & $p<0.01$) were all individually removed and models compared using the likelihood ratio test and assessment of the Akaike Information Criterion, and retained in the model if removal indicated no improvement to model fit.

The use of stages decreasing significance thresholds was adopted due to the increased chance of detecting very small significant differences from the large sample size, and to minimise negative impacts of possible overfitting. It is feasible this approach does not produce the best

model for the sample, but is practical for a very large sample where some covariates are for rare diseases, and to attempt to remove covariates with minimal clinical differences that otherwise could be found statistically significant if using a higher significance level.

### Covariates considered

The following covariates were selected in the univariate analysis and carried forward to the model fitting as described above

### Surgery factors

- Surgeon grade

### Patient factors

- Ability to lie flat and/or cooperate
- Age at surgery
- Diabetic status
- Gender
- Age and gender interaction

### Ocular factors

- Anterior chamber depth
- First / Second operated eye
- Preoperative VA
- Previous Anti-VEGF therapy
- Pupil size

### Ocular co-pathology / known risk factor (presence or absence)

- Age-related Macular Degeneration
- Amblyopia
- Brunescent / White / Mature Cataract
- Corneal Pathology
- Diabetic Retinopathy
- Fuchs Endothelial Dystrophy

- Glaucoma
- High Myopia
- Inherited Eye Disease
- No Fundal View / Vitreous Opacity
- Oculomotor disease
- Other Macular Pathology
- Other Retinal Vascular Pathology
- Previous Trabeculectomy surgery
- Previous Vitrectomy surgery
- Pseudoexfoliation / Phacodenesis
- Uveitis / Synechiae

### Covariates not considered

The following covariates were not considered in the risk factor model fitting;

- Axial length – This was not considered as anterior chamber depth was considered instead, and these two measurements are correlated
- Social deprivation – This is a difficult covariate to include in a prospective risk factor model due to different indices in use in different UK nation which does not match very well, and the RCOphth NOD not receiving this information from many participating centres due to the required matching during data extraction not a working function on their data collection system
- The presence of adnexal problems – This was not considered to be linked to the risk of PCR
- The presence of Floppy Iris Syndrome – This is not known prior to surgery, thus not suitable for a prospective risk factor model
- The presence of Optic nerve / Central Nervous System disease – This is likely to be recorded for eyes that are not standard risk eyes and can cover many possible medical conditions with varying levels of issues for the patient
- Unspecified ‘other’ ocular co-pathology – This is a generic term that is often without a reason why it was recorded. It is also the easiest way for a surgeon to ‘game the system’

# 5 PCR model results

Eligible for the risk factor modelling were 961,208 cataract operations performed in 136 participating centres: 73 English NHS trusts (578,683; 60.2%), 58 ISTCs providing NHS funded and private fee-paying surgery (365,295; 38.0%), three Welsh health boards (12,528; 1.3%), one centre from Guernsey (2,415; 0.3%) and one private fee-paying provider (2,287; 0.2%). The 961,208 operations were performed on 473,074 (49.2%) left eyes and 488,134 (50.8%) right eyes from 682,381 patients by 3,198 surgeons, 686 (21.5%) of whom had data for more than one grade of surgeon where;

- 1,521 consultant surgeons performed 738,527 (76.8%) operations
- 349 career grade non-consultant surgeons performed 57,629 (6.0%) operations
- 1,571 more experienced resident surgeons performed 141,452 (14.7%) operations
- 443 less experienced resident surgeons performed 23,600 (2.5%) operations

### Univariate analysis

At the univariate level all categorical covariates showed association at the 1% level ($p>0.01$) except for the presence or absence of;

- Fuchs endothelial dystrophy ($p=0.052$)
- Inherited eye disease ($p=0.040$)
- Oculomotor disease ($p=0.068$)
- Other macular pathology ($p=0.943$)

For continuous covariates, univariate analysis did not show any association for ACD ($p=0.440$) (Table 1).

**Table 1:** Univariate analysis results

| PCR risk factor model covariates | No PCR | PCR | Total | PCR % | p-value |
|---|---|---|---|---|---|
| Number of operations | 951 478 | 9 730 | 961 208 | 1.01 | N/A |
| **Surgical factors** | | | | | |
| **Surgeon grade** | | | | | |
| Consultant surgeon | 732 857 | 5 670 | 738 527 | 0.77 | <0.001 |
| Career grade non-consultant surgeon | 56 908 | 721 | 57 629 | 1.25 | |
| More experienced resident surgeon | 138 728 | 2 724 | 141 452 | 1.93 | |
| Less experienced resident surgeon | 22 985 | 615 | 23 600 | 2.61 | |
| **Patient factors** | | | | | |
| **Age at surgery (year)** | | | | | |
| Mean | 74.52 | 75.00 | 74.52 | 1.01 | <0.001 |
| Standard deviation | 9.81 | 10.65 | 9.82 | | |
| **Gender** | | | | | |
| Female | 551 736 | 5 154 | 556 890 | 0.93 | <0.001 |
| Male | 399 742 | 4 576 | 404 318 | 1.13 | |
| **Ability to lie flat and cooperate** | | | | | |
| Yes | 919 597 | 9 312 | 928 909 | 1.00 | <0.001 |
| No | 31 881 | 418 | 32 299 | 1.29 | |
| **Systemic diabetes** | | | | | |
| No | 807 527 | 7 577 | 815 104 | 0.93 | <0.001 |
| Yes | 143 951 | 2 153 | 146 104 | 1.47 | |
| **Ocular factors** | | | | | |
| **First or second treated eye*** | | | | | |
| First | 563 894 | 6 160 | 570 054 | 1.08 | <0.001 |
| Second | 387 584 | 3 570 | 391 154 | 0.91 | |
| **Previous intravitreal anti-VEGF therapy** | | | | | |
| No | 929 424 | 9 239 | 938 663 | 0.98 | <0.001 |
| Yes | 22 054 | 491 | 22 545 | 2.18 | |
| **Pupil size** | | | | | |
| Small | 51 309 | 928 | 52 237 | 1.78 | <0.001 |
| Medium | 277 382 | 2 967 | 280 349 | 1.06 | |
| Large | 595 129 | 5 533 | 600 662 | 0.92 | |
| Not recorded | 27 658 | 302 | 27 960 | 1.08 | |

| | | | | | |
|---|---|---|---|---|---|
| **Anterior chamber depth (mm)** | | | | | |
| Mean | 3.08 | 3.08 | 3.08 | 1.01 | 0.440 |
| Standard deviation | 0.42 | 0.46 | 0.42 | | |
| **Preoperative visual acuity (LogMAR)** | | | | | |
| Mean | 0.59 | 0.82 | 0.60 | 1.01 | <0.001 |
| Standard deviation | 0.50 | 0.68 | 0.50 | | |
| **Ocular co-pathology/known risk factor** | | | | | |
| **Age-related macular degeneration** | | | | | |
| No | 853 235 | 8 632 | 861 867 | 1.00 | 0.002 |
| Yes | 98 243 | 1 098 | 99 341 | 1.11 | |
| **Amblyopia** | | | | | |
| No | 936 791 | 9 502 | 946 293 | 1.00 | <0.001 |
| Yes | 14 687 | 228 | 14 915 | 1.53 | |
| **Brunescent / white / mature cataract** | | | | | |
| No | 900 525 | 8 164 | 908 689 | 0.90 | <0.001 |
| Yes | 50 953 | 1 566 | 52 519 | 2.99 | |
| **Corneal pathology** | | | | | |
| No | 882 269 | 9 209 | 891 478 | 1.03 | <0.001 |
| Yes | 69 209 | 521 | 69 730 | 0.75 | |
| **Diabetic retinopathy** | | | | | |
| No | 902 058 | 8 864 | 910 922 | 0.97 | <0.001 |
| Yes | 49 420 | 866 | 50 286 | 1.72 | |
| **Fuchs endothelial dystrophy** | | | | | |
| No | 949 186 | 9 716 | 958 902 | 1.01 | 0.052 |
| Yes | 2 292 | 14 | 2 306 | 0.61 | |
| **Glaucoma** | | | | | |
| No | 864 599 | 8 147 | 872 746 | 0.93 | <0.001 |
| Yes | 86 879 | 1 583 | 88 462 | 1.79 | |
| **High myopia** | | | | | |
| No | 920 242 | 9 310 | 929 552 | 1.00 | <0.001 |
| Yes | 31 236 | 420 | 31 656 | 1.33 | |
| **Inherited eye disease** | | | | | |
| No | 945 734 | 9 687 | 955 421 | 1.01 | 0.040 |
| Yes | 5 744 | 43 | 5 787 | 0.74 | |

| | | | | | |
|---|---|---|---|---|---|
| **No fundal view / vitreous opacity** | | | | | |
| No | 925 708 | 9 096 | 934 804 | 0.97 | <0.001 |
| Yes | 25 770 | 634 | 26 404 | 2.40 | |
| **Oculomotor disease** | | | | | |
| No | 949 782 | 9 705 | 959 487 | 1.01 | 0.068 |
| Yes | 1 696 | 25 | 1 721 | 1.45 | |
| **Other macular pathology** | | | | | |
| No | 914 577 | 9 354 | 923 931 | 1.01 | 0.943 |
| Yes | 36 901 | 376 | 37 277 | 1.01 | |
| **Other retinal vascular pathology** | | | | | |
| No | 942 729 | 9 583 | 952 312 | 1.01 | <0.001 |
| Yes | 8 749 | 147 | 8 896 | 1.65 | |
| **Previous trabeculectomy** | | | | | |
| No | 948 226 | 9 678 | 957 904 | 1.01 | 0.001 |
| Yes | 3 252 | 52 | 3 304 | 1.57 | |
| **Previous vitrectomy** | | | | | |
| No | 936 330 | 9 473 | 945 803 | 1.00 | <0.001 |
| Yes | 15 148 | 257 | 15 405 | 1.67 | |
| **Pseudoexfoliation / phacodonesis** | | | | | |
| No | 943 449 | 9 322 | 952 771 | 0.98 | <0.001 |
| Yes | 8 029 | 408 | 8 437 | 4.84 | |
| **Uveitis / synechiae** | | | | | |
| No | 945 760 | 9 647 | 955 407 | 1.01 | 0.001 |
| Yes | 5 718 | 83 | 5 801 | 1.43 | |

*First treated eye surgery includes both eyes from Immediate Sequential Bilateral Cataract Surgery (ISBCS) patients

### Risk factor modelling

During the risk factor model fitting process, the five covariates were removed due to no association at the 1% level ($p>0.01$), these were the presence or absence of;

- Age-related macular degeneration
- No fundal view / vitreous opacity
- Other retinal vascular pathology
- Previous trabeculectomy surgery
- Uveitis / synechiae

Both the presence or absence of amblyopia and corneal pathology implied association between the 0.1% and 1% level ($p>0.001$ & $p<0.01$). Removing amblyopia did not improve the model fit and was retained. A similar finding was seen for corneal pathology with the decision made to not include this due to the implied protective effect from its presence, and because there can be large variation in why a surgeon would record this (e.g. a small peripheral scar or full thickness central opacity).

The best fitting final model had an area under the receiver curve estimate of 70.0% and included one surgical factor, five patient factors, five ocular factors and seven ocular co-pathology / known risk factor, (Table 2).

The final model included the following;

### Surgical factors

- Surgeon grade

### Patient factors

- Ability to lie flat and/or cooperate
- Age at surgery
- Diabetic status
- Gender
- Age at surgery and gender interaction term

### Ocular factors

- Anterior chamber depth
- First or second eye surgery
- Preoperative VA
- Previous anti-VEGF therapy
- Pupil size

### Ocular co-pathology / known risk factor (presence or absence)

- Amblyopia
- Brunescent / white / mature cataract
- Diabetic retinopathy
- Glaucoma
- High myopia
- Previous vitrectomy surgery
- Pseudoexfoliation / phacodonesis

**Table 2:** PCR risk factor model output

| PCR risk factor model covariates | Odds ratio | Coefficient | Standard error | p-value | 95% confidence interval for odds ratio |
|---|---|---|---|---|---|
| Constant | 0.002 | -6.391 | <0.001 | <0.001 | 0.001 to 0.002 |
| **Surgical factors** | | | | | |
| **Surgeon grade** | | | | | |
| Consultant surgeon | REF | REF | N/A | N/A | N/A |
| Career grade non-consultant surgeon | 1.586 | 0.461 | 0.164 | <0.001 | 1.294 to 1.943 |
| More experienced resident surgeon | 2.484 | 0.910 | 0.100 | <0.001 | 2.296 to 2.688 |
| Less experienced resident surgeon | 3.754 | 1.323 | 0.231 | <0.001 | 3.328 to 4.235 |
| **Patient factors** | | | | | |
| **Age at surgery (year)** | 1.015 | 0.015 | 0.002 | <0.001 | 1.012 to 1.018 |
| **Gender** | | | | | |
| Female | REF | REF | N/A | N/A | N/A |
| Male | 3.046 | 1.114 | 0.485 | <0.001 | 2.229 to 4.162 |
| **Gender and age interaction*** | 0.987 | -0.013 | 0.002 | <0.001 | 0.983 to 0.991 |
| **Ability to lie flat and cooperate** | | | | | |
| Yes | REF | REF | N/A | N/A | N/A |
| No | 1.186 | 0.171 | 0.063 | 0.001 | 1.069 to 1.317 |
| **Systemic diabetes** | | | | | |
| No | REF | REF | N/A | N/A | N/A |
| Yes | 1.239 | 0.215 | 0.043 | <0.001 | 1.157 to 1.327 |
| **Ocular factors** | | | | | |
| **First or second treated eye** | | | | | |
| First | REF | REF | N/A | N/A | N/A |
| Second | 0.904 | -0.101 | 0.019 | <0.001 | 0.868 to 0.942 |
| **Previous intravitreal anti-VEGF therapy** | | | | | |
| No | REF | REF | N/A | N/A | N/A |
| Yes | 1.427 | 0.356 | 0.075 | <0.001 | 1.287 to 1.582 |
| **Pupil size** | | | | | |
| Small | REF | REF | N/A | N/A | N/A |
| Medium | 0.655 | -0.424 | 0.032 | <0.001 | 0.596 to 0.720 |
| Large | 0.648 | -0.434 | 0.027 | <0.001 | 0.596 to 0.703 |
| Not recorded | 0.657 | -0.420 | 0.059 | <0.001 | 0.550 to 0.783 |

| | | | | | |
|---|---|---|---|---|---|
| **Anterior chamber depth (mm)** | 1.113 | 0.107 | 0.033 | <0.001 | 1.051 to 1.178 |
| **Preoperative visual acuity (LogMAR)** | 1.510 | 0.412 | 0.028 | <0.001 | 1.457 to 1.566 |
| **Ocular co-pathology / known risk factor**** | | | | | |
| **Amblyopia** | 1.205 | 0.187 | 0.083 | 0.007 | 1.052 to 1.380 |
| **Brunescent / white / mature cataract** | 2.409 | 0.879 | 0.092 | <0.001 | 2.236 to 2.595 |
| **Diabetic retinopathy** | 1.176 | 0.162 | 0.058 | 0.001 | 1.068 to 1.294 |
| **Glaucoma** | 1.713 | 0.538 | 0.074 | <0.001 | 1.574 to 1.863 |
| **High myopia** | 1.395 | 0.333 | 0.075 | <0.001 | 1.256 to 1.550 |
| **Previous vitrectomy** | 1.241 | 0.216 | 0.084 | 0.001 | 1.086 to 1.417 |
| **Pseudoexfoliation / phacodonesis** | 3.466 | 1.243 | 0.228 | <0.001 | 3.048 to 3.942 |

*For the gender and age interaction, the reference would be female patients

**For all ocular co-pathology / known risk factors, the reference category is absence of the condition (i.e., eyes without the condition)

For the continuous covariates, interpretation of the odds ratios is such that a one-unit change alters the odds by the percentage the ratio implies. For example, each one-year increase in age leads to a 1.5% increase in the age odds whereas each 1.00 LogMAR increase leads to a 51.0% increase in the VA odds (0.10 LogMAR increase leads to a 5.1% increase in the VA odds).

The highest influencing risk factors were surgery by less experienced resident surgeon and pseudoexfoliation / phacodonesis, where the odds ratios were >3 (Figure 1), as was the case for male gender but this large odds ratio is mitigated by the age and gender interaction which reduces the risk for a male patient according to his age, where the older a male patient is, the lower his PCR risk is compared to that of a female patient of the same age (Figure 2).

**Figure 1**: PCR risk factor model odds ratios

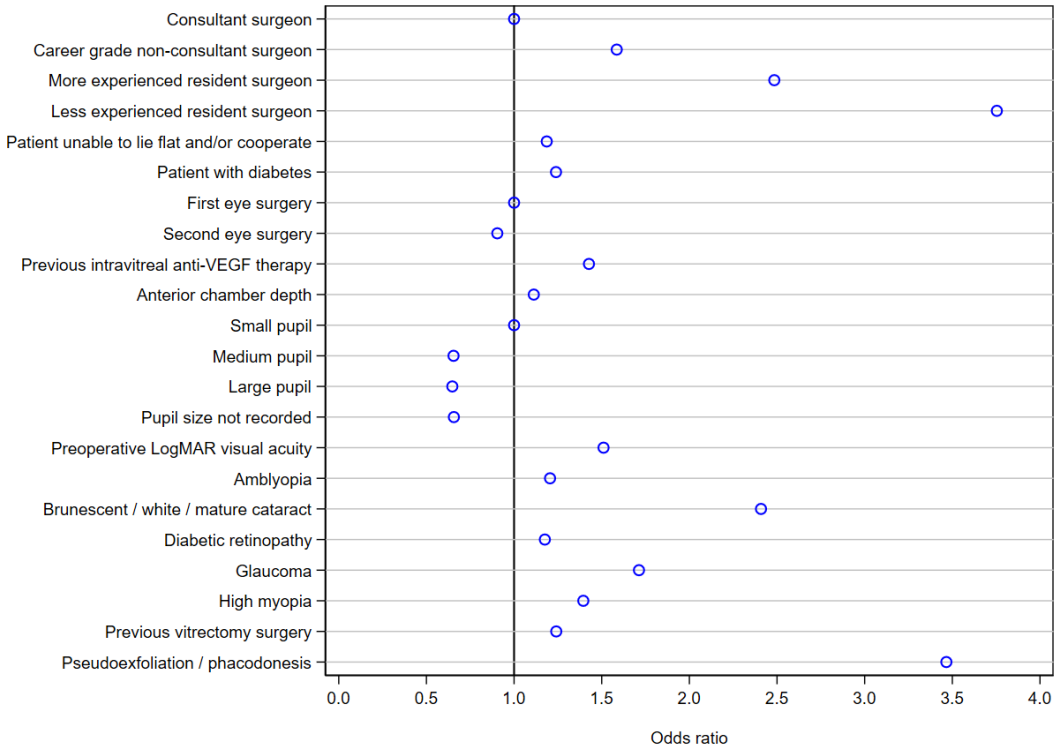
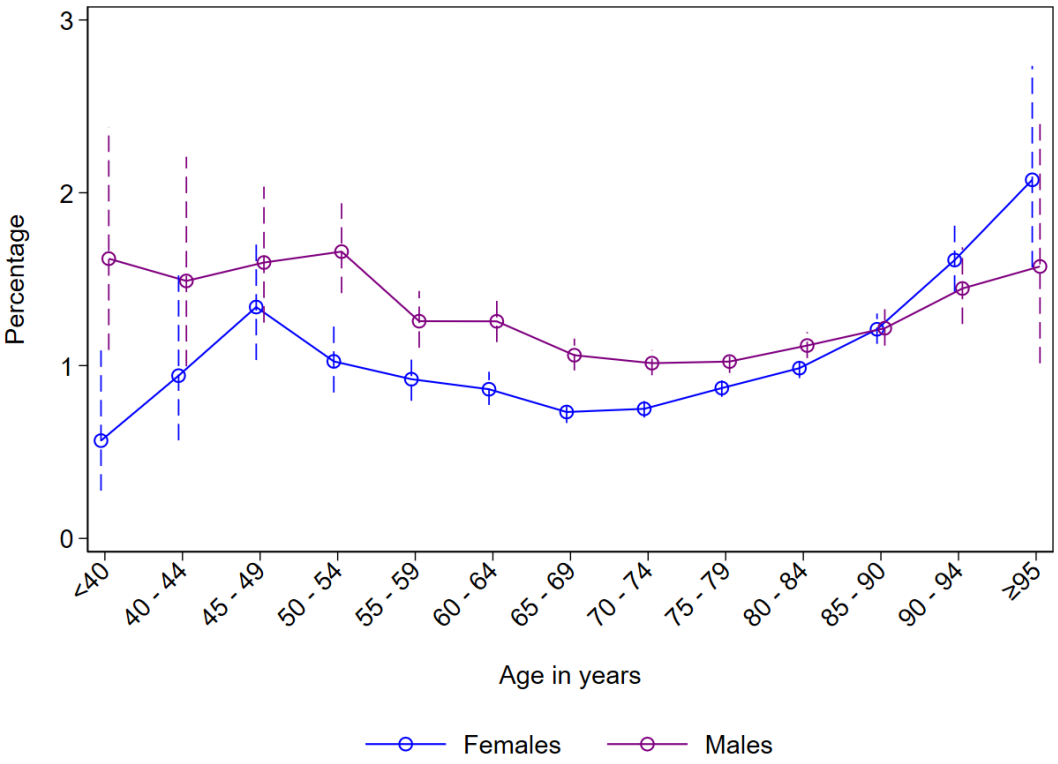



**Figure 2**: PCR percentages with confidence intervals for 5-year age bandings for female and male patients



Certain identified risk factors such as systemic diabetes, diabetic retinopathy, small pupil and previous vitrectomy were more prevalent in male than female patients (Table 3), and differences were also present between first treated eye surgery and second treated eye surgery (Table 4).

The underlying risk of PCR for preoperative VA follows a near linear progression where worse levels of VA have a higher risk of PCR (Figure 3). For Anterior chamber depth, the underlying risk of PCR is higher for eyes with a shallow anterior chamber (<2.2mm) (Figure 4).

**Table 3:** The proportion of operations with the surgical, ocular and ocular comorbidity risk factors for male and female patients (except for first or second eye surgery)

| PCR risk factor model covariates | Male | Female |
|---|---|---|
| Number of eyes | 404,318 | 556,890 |
| **Surgical factors** | | |
| **Surgeon grade** | | |
| Consultant surgeon | 76.9 | 76.8 |
| Career grade non-consultant surgeon | 6.0 | 6.0 |
| More experienced resident surgeon | 14.7 | 14.7 |
| Less experienced resident surgeon | 2.4 | 2.5 |
| **Ocular factors** | | |
| Previous intravitreal anti-VEGF therapy | 2.4 | 2.3 |
| **Pupil size** | | |
| Small | 7.0 | 4.3 |
| Medium | 29.6 | 28.8 |
| Large | 60.5 | 64.0 |
| Not recorded | 2.9 | 2.9 |
| **Anterior chamber depth (mm)** | | |
| <2.00 | 0.2 | 0.3 |
| 2.00 – 2.49 | 7.0 | 9.7 |
| 2.50 – 2.99 | 28.8 | 36.7 |
| 3.00 – 3.49 | 42.8 | 40.6 |
| 3.50 – 3.99 | 19.1 | 11.9 |
| ≥4.00 | 2.1 | 0.9 |
| **Preoperative visual acuity (LogMAR)** | | |
| <0.00 | 0.5 | 0.3 |
| 0.00 – 0.29 | 17.6 | 17.1 |
| 0.30 – 0.59 | 43.0 | 45.7 |
| 0.60 – 0.89 | 20.9 | 20.6 |
| 0.90 – 1.19 | 8.4 | 7.5 |
| 1.20 – 1.49 | 2.6 | 2.3 |
| 1.50 – 1.78 | 1.0 | 1.0 |
| CF, HM, PL or NPL | 6.1 | 5.4 |
| **Ocular co-pathology / known risk factor (presence)** | | |
| Amblyopia | 1.6 | 1.5 |
| Brunescent / white / mature cataract | 6.0 | 5.1 |
| Diabetic retinopathy | 6.6 | 4.2 |
| Glaucoma | 9.7 | 8.9 |
| High myopia | 3.5 | 3.2 |
| Previous vitrectomy | 2.0 | 1.3 |
| Pseudoexfoliation / phacodonesis | 0.8 | 0.9 |

**Table 4:** The proportion of operations with the patient risk factors for male and female patients, separated into first eyes surgery, second eye surgery or ISBCS

| Patient factors | Male | Female |
|---|---|---|
| **First eye surgery** | | |
| **Number of patients** | 242 582 | 326 572 |
| Able to lie flat and cooperate | 3.0 | 3.6 |
| Systemic diabetes | 17.6 | 12.4 |
| **Age at surgery (year)** | | |
| <40 | 0.5 | 0.3 |
| 40 - 49 | 1.7 | 1.3 |
| 50 – 59 | 7.5 | 6.0 |
| 60 – 69 | 20.3 | 18.9 |
| 70 – 79 | 38.9 | 40.9 |
| 80 – 89 | 28.1 | 29.3 |
| ≥90 | 3.0 | 3.3 |
| **Second eye surgery** | | |
| **Number of patients** | 161 358 | 229 796 |
| Able to lie flat and cooperate | 3.0 | 3.5 |
| Patient has diabetes | 19.4 | 13.6 |
| **Age at surgery (year)** | | |
| <40 | 0.3 | 0.2 |
| 40 - 49 | 1.1 | 0.9 |
| 50 – 59 | 6.0 | 4.8 |
| 60 – 69 | 18.5 | 17.2 |
| 70 – 79 | 39.5 | 41.4 |
| 80 – 89 | 31.0 | 31.8 |
| ≥90 | 3.5 | 3.6 |
| **Immediate Sequential Bilateral Cataract Surgery (ISBCS)** | | |
| **Number of patients** | 189 | 261 |
| Able to lie flat and cooperate | 10.6 | 11.5 |
| Systemic diabetes | 16.9 | 15.7 |
| **Age at surgery (year)** | | |
| <40 | 2.6 | 1.1 |
| 40 - 49 | 5.3 | 1.9 |
| 50 – 59 | 12.2 | 10.3 |
| 60 – 69 | 21.7 | 19.5 |
| 70 – 79 | 31.7 | 33.7 |
| 80 – 89 | 24.9 | 29.1 |
| ≥90 | 1.6 | 4.2 |

**Figure 3**: PCR percentages and confidence intervals for preoperative LogMAR VA

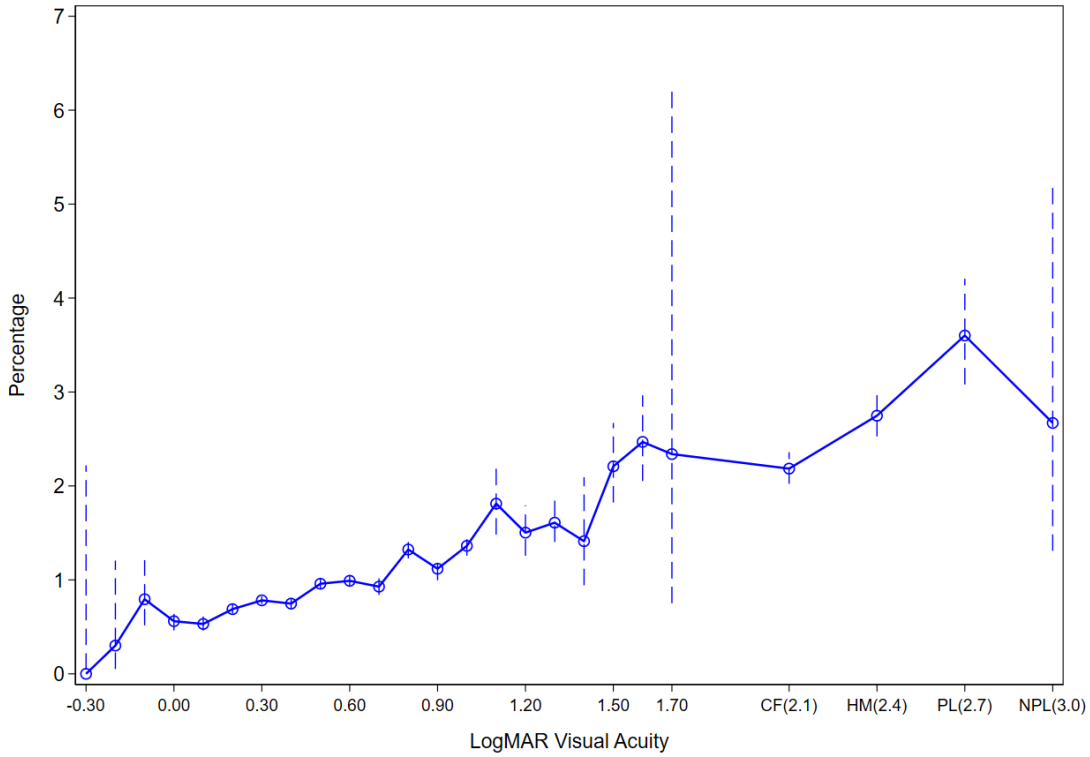
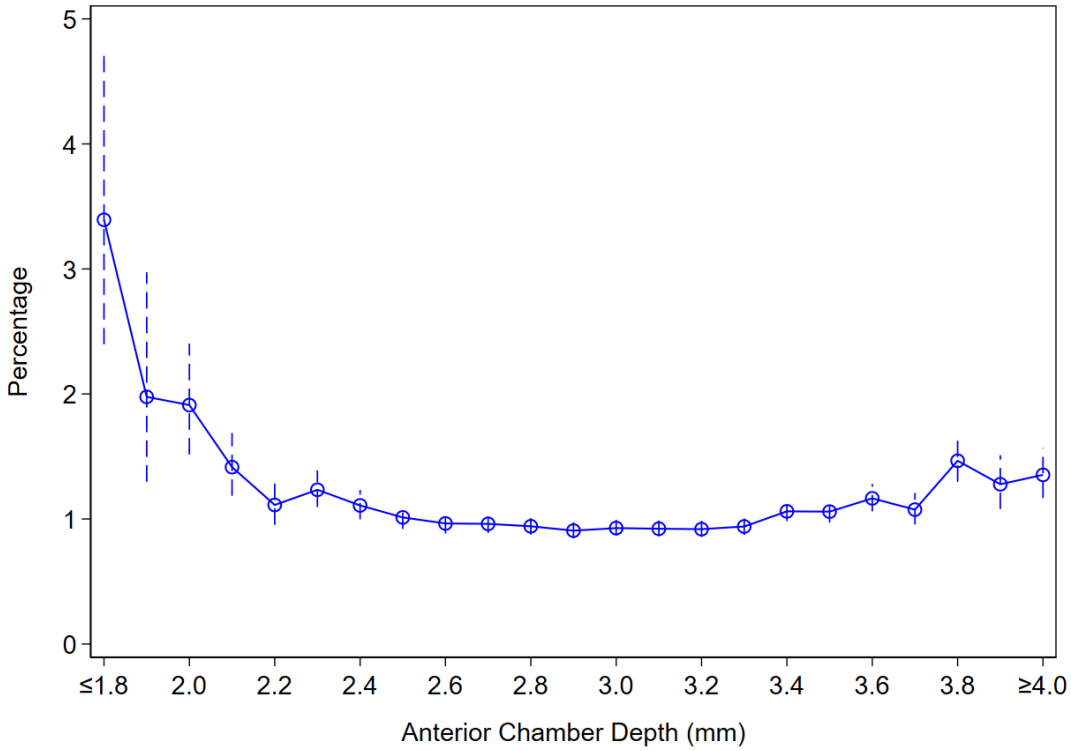



**Figure 4**: PCR percentages with confidence intervals for 0.1 mm increments of ACD



### Risk of PCR examples

An example for first eye surgery on an 80-year-old female patient who can lie flat and cooperate with systemic diabetes, median ACD of 3.08mm, median preoperative VA of 0.50 LogMAR, a large pupil, no previous intravitreal anti-VEGF therapy, and none of the ocular co-pathology / known risk factors, the estimated probability of PCR is 0.77% when the surgery had been performed by a consultant surgeon, and 2.82% when the surgery had been performed by a less experienced resident.

For a male patient with the same age and ocular characteristics as the example female patient, the estimated probability of PCR is 0.82% when surgery was performed by a consultant surgeon, and 3.02% when performed by a less experienced resident surgeon.

# 6 Comparison with previous PCR model

The updated PCR risk factor model is a big improvement to the previous PCR risk factor model that was used in estimated case complexity adjusted PCR rates in audit years 1 to 7. There are many reasons for the improvement including; the sample used for the updated PCR risk factor model was far larger than the sample used for the previous model, with data for more recently performed cataract operations from many more centres using more accurate data from multiple different electronic data collection systems. Additionally, some covariates were fitted as continuous covariates instead of being dichotomised, inclusion of covariates that previously could not be investigated, and the updated model includes an interaction term for the patient's gender and age at surgery, which better accounts for the varying differences in risk across the age spectrum between male and female patients.

### Covariates included in both the previous and updated PCR models

There are ten covariates that were present in the previous PCR model that are included in the updated PCR model, where two of these were fitted differently in the previous PCR model. These ten covariates are;

- Surgeon grade
- Ability to lie flat and/or cooperate*
- Age at surgery*
- Gender
- First / Second eye surgery
- Amblyopia
- Brunescent / White / Mature Cataract
- Diabetic Retinopathy
- High Myopia
- Pseudoexfoliation / Phacodenesis

*Covariates fitted differently

### Covariates now included that were previous not

There are eight covariates that are now included in the updated PCR risk factor model which were not included in the previous model, these are;

- Age and gender interaction
- Anterior Chamber Depth
- Diabetic status
- Preoperative VA
- Previous Anti-VEGF therapy
- Pupil size
- Glaucoma
- Previous Vitrectomy surgery

### Covariates no longer used in PCR adjustment

There are three covariates that were included in the previous PCR model that are not included in the updated PCR model, and will no longer be used in case complexity adjusted PCR estimation, these are;

- No Fundal View / Vitreous Opacity
- Previous Trabeculectomy surgery
- Unspecified 'Other' Ocular Co-pathology

# 7 PCR model limitations

Any risk model can only be as good as the quality of data collected and it is unlikely that all theoretically plausible risk factors can be investigated, due to data collection, funding and time constraints. The RCOphth NOD is committed to using risk models based on scientific evidence and reflect current practice as accurately as possible. If new risk factors are discovered the RCOphth NOD will attempt with the resources available at that time to account for this new information and when time is available.

The current case complexity adjustment PCR model is not a perfect fit to the data and future iterations could be improved by improved data collection. Any statistical model has limitations and for this PCR risk factor model the limitations include;

- Differences between centres in data collection for preoperative assessments
- Potentially influential variables not considered
- A large sample with many of the ocular diseases relatively rare events
- A high number of significant covariates indicating possible model over-fitting
- Area under the operating receiver curve value of 70.0% implies there is unaccounted for variation
- Not able to fit pseudoexfoliation and phacodenesis as separate terms
- >40% sample had bilateral cataract surgery which introduces patient correlation

# 8 Inferring missing values for implementing the PCR model

The PCR model contains covariates that data may not be recorded for each operation, or for some centres not be possible to record on their electronic data collection system. For this reason, the RCOphth NOD has developed rules for inferring missing data when using the PCR model to calculate the expected PCR probability.

The rules for inferring missing data for the PCR model covariates are as follows;

### Categorical and binary covariates

- Surgeon grade – when this cannot be determined after the extensive cross-checking process for the operating surgeon grade, then the operative record is excluded from all National Cataract Audit results
- Ability to lie flat and/or cooperate – when this data is missing the assumption is that the patient could lie flat and cooperate
- Diabetic status – when this data is missing the assumption is that the patient does not have diabetes mellitus
- Gender – when this data is missing the patient is assumed to be a female patient as female patients have a general lower underlying risk of PCR
- First or second eye surgery – when this data is missing the operation is assumed to be performed on the patients first treated eye
- Previous anti-VEGF therapy – when this data is missing the assumption is that the eye has not previously received anti-VEGF therapy
- Pupil size – when this data is missing then 'not recorded' pupil size is allocated
- Ocular co-pathology / known risk factor – when data is missing for the ocular co-pathology / known risk factor, then 'absence' is assumed. Annual data processing includes extensive checking of data received for the ocular co-pathology / known risk factor with more details on this process available on the RCOphth NOD website (www.nodaudit.org.uk/healthcare-professionals/resources)

### Continuous covariates

- Age at surgery – Infer the median value from the operative records when the data is recorded from the latest 5 NHS years. Infer separately for first and second eye surgery
- Anterior chamber depth – Infer the median value from the operative records when the data is recorded from the latest 5 NHS years. Also infer this median value if the recorded anterior chamber depth is <1 mm or >5 mm.
- Preoperative VA - Infer the median value from the operative records when the data is recorded from the latest 5 NHS years. Calculate this median value separately for first and second eye surgery, and according to the source of data (NHS Trusts / Local Health Boards, Independent Sector Treatment Centres, Private fee-paying providers and Guernsey)

# 9 Audit reporting destinations

**Reporting destinations**

The prospective national cataract audit results are published in annual reports available on the RCOphth NOD website. Results for centres are supplied to the Care Quality Commission (CQC) and on the completion of an audit year; a data set is uploaded to www.data.gov.uk and is accessed by the Getting It Right First Time Programme (GIRFT).

Annual reports - Centre adjusted PCR results are provided for all operations performed in a centre including operations performed by resident surgeons. A minimum of 50 eligible operations per centre is required for inclusion. Case mix adjusted graphs will display the 95% and 99.8% confidence intervals.

For the CQC - Centre adjusted PCR results are provided for all operations performed in a centre including operations performed by resident surgeons. A minimum of 50 eligible operations per centre is required for inclusion. The CQC will have the data for displaying both the 95% and 99.8% confidence intervals.

For the RCOphth NOD website (www.nodaudit.org.uk):

Behind the secure log-in - Centre and surgeon unadjusted and adjusted PCR results are available behind a secure log-in for access by relevant staff in participating centres. Date searching functionality is available when the data covers a period longer than the official prospective audit year. Filtering results by surgeon grade and location of surgery are planned future developments of the website. The adjusted graphs display the 95% and 99.8% confidence intervals. The aim is for clinical staff from participating centres to be able to use these results for internal audits and revalidation.

Public facing – The RCOphth NOD website has a public facing section where centres and individual surgeons adjusted PCR results for the latest audit year are available. All surgeons' data is included in the centres' results, while named surgeons' results do not include resident doctors or operations when the fully qualified surgeon performed a resident surgeon.
For data www.data.gov.uk – Once reporting of the data to all sources has been completed the audit data sets are uploaded to www.data.gov.uk.

For GIRFT – Once the data sets have been uploaded to www.data.gov.uk, the GIRFT programme are informed so that the GIRFT team can access the data for their use.

## 10 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.
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.