

**The Royal College of Ophthalmologists' National Ophthalmology  
Database study of cataract surgery: Report 17, a risk factor model  
for posterior capsule rupture**

**Running Title:** RCOphth NOD posterior capsule rupture risk factor model

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## **Abstract**

### **Background/Objectives**

To create a risk factor model for posterior capsule rupture (PCR) during cataract surgery.

### **Subjects/Methods**

Eligible operations between 01/04/2016 and 31/03/2022 from centres supplying data to the UK national cataract audit with complete data including patients' gender and age at surgery, anterior chamber depth (ACD) measurement and preoperative visual acuity (VA) were included. A logistic regression model was fitted to identify risk factors and calculate their odds ratios (OR) and 95% confidence intervals (CI) for PCR.

### **Results**

This analysis included 961 208 cataract operations performed on 682 381 patients from 136 participating centres by 3 198 surgeons. 9 730 (1.01%) of surgeries were complicated by PCR. The median age was 75.7 and 76.7 years for first and second eye surgery respectively, and 5 154 (53.0%) were female. The highest risk factors for PCR were less experienced trainee surgeon (OR 3.75, 95% CI 3.33-4.24,  $p<0.001$ ), pseudoexfoliation / phacodonesis (OR 3.47, 95% CI 3.05-3.94,  $p<0.001$ ), younger males (OR 3.05, 95% CI 2.23-4.16,  $p<0.001$ ) and brunescant / white / mature cataract (OR 2.41, 95% CI 2.24-2.60,  $p<0.001$ ). Other risk factors identified were glaucoma, worse preoperative VA, previous intravitreal therapy, high myopia, previous vitrectomy, systemic diabetes, diabetic retinopathy, amblyopia, older age, shallower ACD and inability to lie flat and cooperate.

### **Conclusion**

Various surgical, patient and ocular factors increase the risk of PCR during cataract surgery. This risk factor model permits estimation of individualised risks for patients and allows risk-adjustment for surgeons to evaluate their PCR rates based on case complexity.

## Introduction

Cataract surgery continues to be the most commonly performed elective surgical procedure in the UK, with around 600 000 operations performed in the 2022-2023 NHS year. Since its inception in 2010, the Royal College of Ophthalmologists National Ophthalmology Database (RCOphth NOD) audit has established itself as an important quality assurance measure and research tool, with several analyses published over the last decade<sup>1-13</sup>. Given its ever expanding dataset, there is a need for continual analyses to ensure up-to-date, high-quality evidence to drive quality improvement and national benchmarking of surgical outcomes.

Posterior capsular rupture (PCR) remains one of the most common complications of cataract surgery and is a risk factor for poor visual prognosis<sup>14</sup>. Following PCR, there is a higher relative risk (RR) of severe vision loss (RR, 15.5) [publication pending] and secondary complications such as cystoid macular oedema (RR, 2.6)<sup>15</sup>, endophthalmitis (RR, 7.2)<sup>10</sup> and retinal detachment (RR, 20.4)<sup>3</sup>. PCR also imposes a substantial additional financial cost burden to health care systems due to the need for additional visits and interventions<sup>16,17</sup>.

This RCOphth NOD analysis aims to provide an update to the now 15-year-old risk stratification system for PCR from the previous Cataract National Dataset<sup>18</sup> and also the RCOphth NOD PCR risk adjustment model fitted in 2015<sup>19</sup>. Over this time period, PCR rates have more than halved from 1.95%<sup>1</sup> to 0.79% in the latest RCOphth NOD audit annual report for 2022-2023<sup>20</sup>. The observed decline has a variety of potential causes, such as the introduction of simulator training amongst trainee surgeons<sup>6</sup>, improvement in instrumentation (e.g. use of silicone-tipped handpieces<sup>21</sup>) and an increasing trend toward surgery on younger and healthier eyes<sup>22</sup>. The determinants of PCR rate are also likely to have changed over time, with more recently reported novel risk factors for PCR such as previous intravitreal injections<sup>23</sup> and corneal opacities<sup>24</sup>. On a global scale, an up-to-date risk stratification system is required to permit meaningful comparison of the RCOphth NOD dataset with those of other

countries<sup>24,25</sup>, to facilitate the development of a bespoke international benchmarking system and to be able to advise patients before surgery of their specific material risk.

## Methods

The RCOphth NOD is open to centres performing both NHS funded and private cataract surgery in England, Northern Ireland, Scotland, Wales, and the Channel Islands which include NHS centres, independent sector treatment centres (ISTCs) and private providers. The data, compliant with the RCOphth minimum national cataract dataset, is recorded on electronic medical records (EMRs) or in-house databases and submitted annually for cataract operations using phacoemulsification to treat patients aged 18 years or older, where the primary intention was cataract surgery and not combined ‘cataract + other’ surgery, unless the ‘other’ surgery formed part of the cataract operation (e.g., an operative manoeuvre to increase pupil size). Cases where PCR is expected as part of surgery, such as posterior polar or traumatic cataracts, are excluded from NOD analyses. Further information on audit eligible cataract operations can be found on the audit website ([www.nodaudit.org.uk](http://www.nodaudit.org.uk)).

The study period comprised cataract operations performed between 01/04/2016 and 31/03/2022 which constitutes 6 completed NHS years. Eligible for this analysis are 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 are 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 are included.

For this analysis, data was recorded on either the Medisoft EMR system (Medisoft Ophthalmology, Medisoft Limited, Leeds, UK, [www.medisoft.co.uk](http://www.medisoft.co.uk)), OpenEyes EMR system ([www.openeyes.org.uk](http://www.openeyes.org.uk)), or in-house databases compliant with the RCOphth national cataract dataset (<https://www.rcophth.ac.uk/standards-and-guidance/audit-and-data/clinical-data-sets>).

The grade of operating surgeon was categorised as consultant surgeons, career grade non-consultant surgeons (associate specialists, staff grades and trust doctors), more experienced trainee surgeons (fellows and specialty trainees / registrars years 3-7), and less experienced trainee 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<sup>26</sup>.

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. For the categorical covariates, only those indicating association at the 1% level ( $p < 0.01$ ) from the univariate analysis were considered in the risk factor modelling. This restriction did not apply to the continuous covariates, which were all 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. The full equation of the final model used to estimate the probability of PCR for each operation is detailed in Supplementary File.

The lead clinician and Caldicott Guardian (responsible nominee for data protection) at each

centre provided written approval for anonymised data extraction. Ethical permission was not required for this analysis due to being viewed as audit or service evaluation. This study was conducted in accordance with the Declaration of Helsinki and the UK Data Protection Act. All analyses were performed using STATA 18 (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC).

## Results

Within the study period, 1 453 374 eligible cataract operations were submitted with data for patients' gender and age. Excluded from this are 492 124 (33.9%) operations for the following reasons; 297 315 had no recorded ACD measurement, 193 080 had no preoperative VA, 1 701 had a recorded ACD of <1.5mm or >4.5mm, and 28 had a recorded AL of <18mm. A further 42 operations from five centres were removed as these centres had <50 operations left in the sample after applying the exclusion criteria above.

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 fully private fee-paying provider (2 287; 0.2%). The range in the number of operations performed by the centres was 144 to 28 414.

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; 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 trainee surgeons performed 141 452 (14.7%) operations and 443 less

experienced trainee surgeons performed 23 600 (2.5%) operations. The median number of operations performed by surgeons was 93 (range; 1 to 21 473).

First eye surgery was performed in 569 154 patients where 326 572 (57.4%) were female and the median age at surgery was 75.7 years (interquartile range; 69.0–81.7 years). Second eye surgery was performed in 391 154 patients where 229 796 (58.7%) were female and the median age at surgery was 76.7 years (interquartile range; 70.2–82.3 years). Immediate sequential bilateral cataract surgery (ISBCS) was performed in 450 patients where 261 (58.0%) patients were female and the median age at surgery was 75.0 years (interquartile range; 65.2–81.8 years). Over the study period, 278 377 (40.8%) non-ISBCS patients had surgery to both eyes, where the median time between the two operations was 3.0 months (range one day to 6.0 years).

#### PCR risk factor model

At the univariate level all categorical covariates showed association at the 1% level ( $p > 0.01$ ) except for Fuchs endothelial dystrophy ( $p = 0.052$ ), inherited eye disease ( $p = 0.040$ ), oculomotor disease ( $p = 0.068$ ) and other macular pathology ( $p = 0.943$ ). For continuous covariates, univariate analysis did not show any association for ACD ( $p = 0.440$ ) (Table 1).

During the risk factor model fitting process, the following covariates were removed due to no association at the 1% level ( $p > 0.01$ ); age-related macular degeneration, no fundal view / vitreous opacity, other retinal vascular pathology, previous trabeculectomy surgery and uveitis / synechiae. Both 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 but a decision was made to not include this due to the implied protective effect from its presence, and also 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 final model included the following surgical and patient factors: surgeon grade, patients' age and gender, ability to lie flat and cooperate, diabetic status and an interaction term between age and gender. Ocular factors were first or second eye surgery, ACD, preoperative VA, previous intravitreal anti-vascular endothelial growth factor (VEGF) therapy, pupil size, amblyopia, brunescient / white / mature cataract, diabetic retinopathy, glaucoma, high myopia, previous vitrectomy surgery and pseudoexfoliation / phacodonesis (Table 2).

The final model had an area under the receiver curve estimate of 70.0%. The highest influencing risk factors were surgery by less experienced trainee surgeon and pseudoexfoliation / phacodonesis, where the odds ratios were  $>3$  (Supplementary Figure), as was the case for male gender but this large odds ratio is mitigated by the age/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 1). Certain identified risk factors such as systemic diabetes, diabetic retinopathy, small pupil and previous vitrectomy were more prevalent in male than female patients (Supplementary Table).

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 2). For ACD, the underlying risk of PCR is higher for eyes with a shallow AC ( $<2.2\text{mm}$ ) (Figure 3). 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).

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242 Risk of PCR examples

243 An example for first eye surgery performed by a consultant surgeon on an 80-year-old female  
244 patient who can lie flat and cooperate with systemic diabetes, median ACD of 3.08mm, median  
245 preoperative VA of 0.50 LogMAR, a large pupil, no previous intravitreal anti-VEGF therapy,  
246 and none of the ocular comorbidities, the estimated probability of PCR is 0.77%. If the surgery  
247 had been performed by a less experienced trainee the estimated probability is 2.82%. For a  
248 male patient with the same age and ocular characteristics, the estimated probability of PCR is  
249 0.82% when surgery was performed by a consultant surgeon, and 3.02% when performed by  
250 a less experienced trainee surgeon. Conversely, the estimated probability of PCR is 0.42%  
251 for a 40-year-old female patient operated on by a consultant, compared to 0.76% for a 40-  
252 year-old male patient with the same ocular characteristics.

253

254 **Discussion**

255

256 The current analysis covers the 2016-2021 NHS years and includes the largest UK national  
257 sample size to date. The selected interval coincides with the period operations have been  
258 performed with access to annual national benchmarks published by the RCOphth NOD,  
259 increasing use of surgical simulators in training and growing provision of surgery by the  
260 independent sector. In addition to providing an update to the current statistical model for case  
261 complexity adjustment, the current analysis has confirmed previously known risk factors for  
262 PCR (advancing age, trainee surgeon, male gender, inability to lie flat and cooperate, systemic  
263 diabetes, diabetic retinopathy, smaller pupil size, mature cataract, glaucoma and  
264 pseudoexfoliation / phacodonesis), corroborated more recently reported risk factors (previous  
265 intravitreal anti-VEGF therapy<sup>23,27,28</sup> and worse preoperative VA<sup>24</sup>) and quantified the impact  
266 of additional risk factors (high myopia, previous vitrectomy, shallow ACD and amblyopia).

267

268 Of particular note compared to the previous UK Cataract National Dataset analysis, the

elevated odds ratio for PCR observed for younger male patients was found to be one of the highest with an adjusted odds ratio of 3.05, however the age/gender interaction term diminishes this ratio in older patients such that there is parity of risk between the genders by age 85, and above 90 years of age females are seen to be at a higher risk of PCR (Figure 1). The inclusion of the interaction term is an attempt to account for the differences across the age range, and assessment of different risks between male and female patients has to be considered in relation to the patient's age. The reasons for these differences are likely to be complex and postulated contributing factors may include greater lifetime accumulation of ocular trauma<sup>29</sup> and less willingness to engage with healthcare services<sup>30</sup> in younger males. Some of the identified risk factors in this analysis were also more prevalent in male than female patients, although the converse is seen for other risk factors, consequently these differences cannot account for all of the observed higher risk for male gender (Supplementary Table).

Our finding of prior intravitreal anti-VEGF injections being associated with increased risk of PCR is consistent with previous studies<sup>23,27,28</sup>. There is currently evidence to suggest that the risk of PCR is dose-dependent and higher for eyes that have received >10 injections<sup>23,28</sup>. However, in our analysis, we were not able to specifically look at the number of prior intravitreal injections so there may be some underestimation of effect. We also found preoperative high myopia to be a significant risk factor for PCR; this is somewhat expected based on prior studies<sup>31,32</sup>. One theorised mechanism for this is the longer AL inherent in these eyes which may make surgery more challenging. However, previous analyses have found no significant association between AL and risk of PCR<sup>2,8</sup>, which would suggest other possible contributory mechanisms in high myopia such as higher cataract density<sup>33</sup>.

Previous studies on the risk of intraoperative complications in eyes with prior pars plana vitrectomy (PPV) have reported mixed findings<sup>24,34</sup>. We found a significantly higher rate of PCR in eyes with previous PPV which could be conferred by altered fluid dynamics<sup>35</sup>, unstable posterior capsules<sup>36</sup> or posterior lenticular touch during vitrectomy<sup>37</sup>. The pathophysiology

underlying the increased risk of PCR in vitrectomised eyes may also have some overlap with that of high myopia given the strong correlation between the two<sup>38</sup>. Similar to previous PPV, there is currently no consensus on whether shallow ACD increases the risk of PCR<sup>39–41</sup>. We found that a shallow ACD of <2.2mm was associated with a significant increase in PCR rates. One possible explanation for this may be that iris prolapse is more common so surgeons make longer tunnels, increasing corneal distortion and impairing visualisation, or more directly increasing proximity of instruments to the posterior capsule in a shallow anterior chamber.

In contrast to the recent European registry analysis which found corneal opacities to be the most significantly associated risk factor for PCR<sup>24</sup>, we found a protective effect of corneal pathology against PCR. The interpretation of this discrepancy is made difficult by the heterogeneity in definition of “corneal opacities” and “corneal pathology” which includes a broad spectrum of phenotype. Nonetheless, one possible explanation for the protective effect of corneal pathology is that there might be a lower threshold for earlier (and hence easier) cataract surgery in affected eyes due to their worse baseline vision.

This study has several limitations. In this analysis, 40.8% patients had bilateral cataract surgery which can introduce patient level correlation impacting on statistical comparisons. Attempting to account for potential patient level correlation was not part of the model fitting, instead cluster adjustment for robust standard errors focused on the operating surgeon, by considering their operations in different centres and for different surgeon grades as separate clusters. This attempted to account for surgeons with different responsibilities and experience over the study period, and them working with different theatre teams and in different hospitals. The decision was made to consider surgeons as clusters instead of patients, as patients will have at most two operations, whereas surgeons can operate on thousands of patients. Furthermore, some ocular diseases can develop as bilateral disease, and some are linked to age and be more prevalent in second treated eyes.

It is possible that not all recorded first treated eye operations were patients' actual first eye surgery, as patients could have their first eye surgery prior to a centre adopting an EMR, or performed in a different centre, and at present the audit cannot link patients' data if collected at different centres. It was also not possible to separate pseudoexfoliation and phacodonesis to fit as individual terms in the modelling due to the current option to record both as a combined term on the EMR systems. Potentially influencing risk factors that were not considered were AL and social deprivation. AL was not considered as it is correlated with ACD and previous studies have shown that AL is not a significant influencer for PCR risk<sup>2,8</sup>. Social deprivation was not considered because the audit did not receive this information from all contributing centres due to the differing data collection systems used, and that there are different indices for the different UK nations.

The PCR risk factor model was not a perfect fit, the area under the operating receiver curve value of 70.0% implies there is unaccounted for variation, and the number of significant covariates is a concern regarding possible overfitting, although this is also a reflection of the various clinical factors that can influence the risk of PCR and is linked to a large sample with many covariates having low event rates. Consequently, the interpretation of p-values require caution as they are likely to be too low, especially for covariates with extremely low event rates.

In summary, this analysis provides an update to the current risk adjustment model for PCR with the quantification of additional risk factors. This will facilitate a bespoke, contemporary risk assessment tailored to an individual patient's operation, thereby allowing more informed patient counselling, appropriate case allocation and adoption of precautionary measures to minimise the risk of PCR during surgery.

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The full list of the 136 participating centres included in this study is detailed in Supplementary File.

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## **Author Contribution**

PYS, PHJD, ACD and JCB conceptualised the study. PHJD prepared the study data and performed the statistical analysis. All authors contributed to interpretation of the results. PYS

378 and PHD wrote the first draft of the manuscript. All authors contributed to critical revision of  
379 the manuscript and approved the final manuscript. JCB is the overall content guarantor.

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## 513 **Table and Figure legends**

514

### 515 **Table 1**

516 Univariate analysis for covariates under consideration for the PCR risk factor modelling. The  
517 PCR rate for the continuous covariates is the overall PCR rate for the sample. N = 961 208  
518 cataract operations performed in 136 centres by 3 198 surgeons.

519

### 520 **Table 2**

521 Final PCR risk factor model estimates. N = 961 208 cataract operations performed in 136  
522 centres by 3 198 surgeons.

523

### 524 **Figure 1**

525 Observed PCR rates for patients' age and gender displayed in 5-year age bandings. N = 961  
526 208 cataract operations performed in 136 centres by 3 198 surgeons. 95% confidence  
527 intervals derived using the Fliess quadratic continuity correction. Estimates plotted at the  
528 boundary -0.25 for females and +0.25 for males for display purposes.

529

### 530 **Figure 2**

531 Observed PCR rates for preoperative LogMAR visual acuity displayed in 0.10 LogMAR  
532 bandings. N = 961 208 cataract operations performed in 136 centres by 3 198 surgeons. 95%  
533 confidence intervals derived using the Fliess quadratic continuity correction.

534

### 535 **Figure 3**

536 Observed PCR rates for anterior chamber depth displayed in 0.1 mm increments. N = 961 208  
537 cataract operations performed in 136 centres by 3 198 surgeons. 95% confidence intervals  
538 derived using the Fliess quadratic continuity correction.

Table 1: Univariate analysis for covariates under consideration for the PCR risk factor modelling. The PCR rate for the continuous covariates is the overall PCR rate for the sample.  
N = 961 208 cataract operations performed in 136 centres by 3 198 surgeons.

| <b>PCR risk factor model covariates univariate analysis</b> | <b>No PCR</b> | <b>PCR</b> | <b>Total</b> | <b>PCR %</b> | <b>p-value</b> |
|-------------------------------------------------------------|---------------|------------|--------------|--------------|----------------|
| Number of operations                                        | 951 478       | 9 730      | 961 208      | 1.01         | N/A            |
| <b>Surgical factors</b>                                     |               |            |              |              |                |
| <b>Surgeon grade</b>                                        |               |            |              |              |                |
| 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 trainee surgeon                            | 138 728       | 2 724      | 141 452      | 1.93         |                |
| Less experienced trainee surgeon                            | 22 985        | 615        | 23 600       | 2.61         |                |
| <b>Patient factors</b>                                      |               |            |              |              |                |
| <b>Age at surgery (year)</b>                                |               |            |              |              |                |
| Mean                                                        | 74.52         | 75.00      | 74.52        | 1.01         | <0.001         |
| Standard deviation                                          | 9.81          | 10.65      | 9.82         |              |                |
| <b>Gender</b>                                               |               |            |              |              |                |
| Female                                                      | 551 736       | 5 154      | 556 890      | 0.93         | <0.001         |
| Male                                                        | 399 742       | 4 576      | 404 318      | 1.13         |                |
| <b>Ability to lie flat and cooperate</b>                    |               |            |              |              |                |
| Yes                                                         | 919 597       | 9 312      | 928 909      | 1.00         | <0.001         |
| No                                                          | 31 881        | 418        | 32 299       | 1.29         |                |
| <b>Systemic diabetes</b>                                    |               |            |              |              |                |
| No                                                          | 807 527       | 7 577      | 815 104      | 0.93         | <0.001         |
| Yes                                                         | 143 951       | 2 153      | 146 104      | 1.47         |                |
| <b>Ocular factors</b>                                       |               |            |              |              |                |
| <b>First or second treated eye*</b>                         |               |            |              |              |                |
| First                                                       | 563 894       | 6 160      | 570 054      | 1.08         | <0.001         |
| Second                                                      | 387 584       | 3 570      | 391 154      | 0.91         |                |
| <b>Previous intravitreal anti-VEGF therapy</b>              |               |            |              |              |                |
| No                                                          | 929 424       | 9 239      | 938 663      | 0.98         | <0.001         |
| Yes                                                         | 22 054        | 491        | 22 545       | 2.18         |                |
| <b>Pupil size</b>                                           |               |            |              |              |                |
| 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         |                |

|                                             |         |       |         |      |        |
|---------------------------------------------|---------|-------|---------|------|--------|
| <b>Anterior chamber depth (mm)</b>          |         |       |         |      |        |
| Mean                                        | 3.08    | 3.08  | 3.08    | 1.01 | 0.440  |
| Standard deviation                          | 0.42    | 0.46  | 0.42    |      |        |
| <b>Preoperative visual acuity (LogMAR)</b>  |         |       |         |      |        |
| Mean                                        | 0.59    | 0.82  | 0.60    | 1.01 | <0.001 |
| Standard deviation                          | 0.50    | 0.68  | 0.50    |      |        |
| <b>Ocular comorbidities</b>                 |         |       |         |      |        |
| <b>Age-related macular degeneration</b>     |         |       |         |      |        |
| No                                          | 853 235 | 8 632 | 861 867 | 1.00 | 0.002  |
| Yes                                         | 98 243  | 1 098 | 99 341  | 1.11 |        |
| <b>Amblyopia</b>                            |         |       |         |      |        |
| No                                          | 936 791 | 9 502 | 946 293 | 1.00 | <0.001 |
| Yes                                         | 14 687  | 228   | 14 915  | 1.53 |        |
| <b>Brunescent / white / mature cataract</b> |         |       |         |      |        |
| No                                          | 900 525 | 8 164 | 908 689 | 0.90 | <0.001 |
| Yes                                         | 50 953  | 1 566 | 52 519  | 2.99 |        |
| <b>Corneal pathology</b>                    |         |       |         |      |        |
| No                                          | 882 269 | 9 209 | 891 478 | 1.03 | <0.001 |
| Yes                                         | 69 209  | 521   | 69 730  | 0.75 |        |
| <b>Diabetic retinopathy</b>                 |         |       |         |      |        |
| No                                          | 902 058 | 8 864 | 910 922 | 0.97 | <0.001 |
| Yes                                         | 49 420  | 866   | 50 286  | 1.72 |        |
| <b>Fuchs endothelial dystrophy</b>          |         |       |         |      |        |
| No                                          | 949 186 | 9 716 | 958 902 | 1.01 | 0.052  |
| Yes                                         | 2 292   | 14    | 2 306   | 0.61 |        |
| <b>Glaucoma</b>                             |         |       |         |      |        |
| No                                          | 864 599 | 8 147 | 872 746 | 0.93 | <0.001 |
| Yes                                         | 86 879  | 1 583 | 88 462  | 1.79 |        |
| <b>High myopia</b>                          |         |       |         |      |        |
| No                                          | 920 242 | 9 310 | 929 552 | 1.00 | <0.001 |
| Yes                                         | 31 236  | 420   | 31 656  | 1.33 |        |
| <b>Inherited eye disease</b>                |         |       |         |      |        |
| No                                          | 945 734 | 9 687 | 955 421 | 1.01 | 0.040  |
| Yes                                         | 5 744   | 43    | 5 787   | 0.74 |        |
| <b>No fundal view / vitreous opacity</b>    |         |       |         |      |        |
| No                                          | 925 708 | 9 096 | 934 804 | 0.97 | <0.001 |
| Yes                                         | 25 770  | 634   | 26 404  | 2.40 |        |
| <b>Oculomotor disease</b>                   |         |       |         |      |        |
| No                                          | 949 782 | 9 705 | 959 487 | 1.01 | 0.068  |
| Yes                                         | 1 696   | 25    | 1 721   | 1.45 |        |

|                                         |         |       |         |      |        |
|-----------------------------------------|---------|-------|---------|------|--------|
| <b>Other macular pathology</b>          |         |       |         |      |        |
| No                                      | 914 577 | 9 354 | 923 931 | 1.01 | 0.943  |
| Yes                                     | 36 901  | 376   | 37 277  | 1.01 |        |
| <b>Other retinal vascular pathology</b> |         |       |         |      |        |
| No                                      | 942 729 | 9 583 | 952 312 | 1.01 | <0.001 |
| Yes                                     | 8 749   | 147   | 8 896   | 1.65 |        |
| <b>Previous trabeculectomy</b>          |         |       |         |      |        |
| No                                      | 948 226 | 9 678 | 957 904 | 1.01 | 0.001  |
| Yes                                     | 3 252   | 52    | 3 304   | 1.57 |        |
| <b>Previous vitrectomy</b>              |         |       |         |      |        |
| No                                      | 936 330 | 9 473 | 945 803 | 1.00 | <0.001 |
| Yes                                     | 15 148  | 257   | 15 405  | 1.67 |        |
| <b>Pseudoexfoliation / phacodonesis</b> |         |       |         |      |        |
| No                                      | 943 449 | 9 322 | 952 771 | 0.98 | <0.001 |
| Yes                                     | 8 029   | 408   | 8 437   | 4.84 |        |
| <b>Uveitis / synechiae</b>              |         |       |         |      |        |
| 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 ISBCS patients



Table 2: Final PCR risk factor model estimates. N = 961 208 cataract operations performed in 136 centres by 3 198 surgeons.

| 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                         |
| <b>Surgical factors</b>                        |            |             |                |         |                                        |
| <b>Surgeon grade</b>                           |            |             |                |         |                                        |
| 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 trainee surgeon               | 2.484      | 0.910       | 0.100          | <0.001  | 2.296 to 2.688                         |
| Less experienced trainee surgeon               | 3.754      | 1.323       | 0.231          | <0.001  | 3.328 to 4.235                         |
| <b>Patient factors</b>                         |            |             |                |         |                                        |
| <b>Age at surgery (year)</b>                   | 1.015      | 0.015       | 0.002          | <0.001  | 1.012 to 1.018                         |
| <b>Gender</b>                                  |            |             |                |         |                                        |
| Female                                         | REF        | REF         | N/A            | N/A     | N/A                                    |
| Male                                           | 3.046      | 1.114       | 0.485          | <0.001  | 2.229 to 4.162                         |
| <b>Gender and age interaction*</b>             | 0.987      | -0.013      | 0.002          | <0.001  | 0.983 to 0.991                         |
| <b>Ability to lie flat and cooperate</b>       |            |             |                |         |                                        |
| Yes                                            | REF        | REF         | N/A            | N/A     | N/A                                    |
| No                                             | 1.186      | 0.171       | 0.063          | 0.001   | 1.069 to 1.317                         |
| <b>Systemic diabetes</b>                       |            |             |                |         |                                        |
| No                                             | REF        | REF         | N/A            | N/A     | N/A                                    |
| Yes                                            | 1.239      | 0.215       | 0.043          | <0.001  | 1.157 to 1.327                         |
| <b>Ocular factors</b>                          |            |             |                |         |                                        |
| <b>First or second treated eye</b>             |            |             |                |         |                                        |
| First                                          | REF        | REF         | N/A            | N/A     | N/A                                    |
| Second                                         | 0.904      | -0.101      | 0.019          | <0.001  | 0.868 to 0.942                         |
| <b>Previous intravitreal anti-VEGF therapy</b> |            |             |                |         |                                        |
| No                                             | REF        | REF         | N/A            | N/A     | N/A                                    |
| Yes                                            | 1.427      | 0.356       | 0.075          | <0.001  | 1.287 to 1.582                         |
| <b>Pupil size</b>                              |            |             |                |         |                                        |
| 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 |
| <b>Anterior chamber depth (mm)</b>          | 1.113 | 0.107  | 0.033 | <0.001 | 1.051 to 1.178 |
| <b>Preoperative visual acuity (LogMAR)</b>  | 1.510 | 0.412  | 0.028 | <0.001 | 1.457 to 1.566 |
| <b>Ocular comorbidities**</b>               |       |        |       |        |                |
| <b>Amblyopia</b>                            | 1.205 | 0.187  | 0.083 | 0.007  | 1.052 to 1.380 |
| <b>Brunescent / white / mature cataract</b> | 2.409 | 0.879  | 0.092 | <0.001 | 2.236 to 2.595 |
| <b>Diabetic retinopathy</b>                 | 1.176 | 0.162  | 0.058 | 0.001  | 1.068 to 1.294 |
| <b>Glaucoma</b>                             | 1.713 | 0.538  | 0.074 | <0.001 | 1.574 to 1.863 |
| <b>High myopia</b>                          | 1.395 | 0.333  | 0.075 | <0.001 | 1.256 to 1.550 |
| <b>Previous vitrectomy</b>                  | 1.241 | 0.216  | 0.084 | 0.001  | 1.086 to 1.417 |
| <b>Pseudoexfoliation / phacodonesis</b>     | 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 comorbidities, the reference category is absence of the condition (i.e., eyes without the condition)





