Developing decision support tools incorporating personalised predictions of likely visual benefit versus harm for cataract surgery: research programme

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Scientific summary

Predict-CAT and Involve-CAT

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Scientific summary

Background

Cataract surgery is the most frequently undertaken surgical procedure in the NHS, with around 450,000 operations performed annually. Understanding the impact of cataracts on a patient's perceptions of their own 'lived vision' in the complex, dynamic, everyday visual environment in which they live is key to establishing the need for surgery. Formal measurement of self-reported visual difficulty related to cataracts can provide important information that is complementary to the standard clinical parameters generally used to assess need for and benefit from surgery.

The programme was divided into four work packages (WPs).

Objectives

Work package 1

- To allow the patient's voice to be more clearly and systematically expressed regarding their visual difficulty through the development and validation of a brief cataract patient-reported outcome measure (PROM) of visual difficulty, named Cataract Patient-Reported Outcome Measure, five items (Cat-PROM5).
- To compare and contrast Cat-PROM5 with the current 'best-of-class', but longer, instrument for use in routine cataract surgical services.

Work package 2

- To validate or update existing risk models for adverse outcomes.
- To assess the stability through time of the risk model for posterior capsule rupture.
- To improve understanding of the rates of adverse outcomes in the growing very elderly population.

Work package 3

Quantitative

- To develop a benefits prediction model for personalised prediction of self-reported benefit from cataract surgery based on Cat-PROM5.

Qualitative

- To inform the development and refinement of a cataract decision aid (CDA) through qualitative research involving patients and health-care professionals (HCPs) to:
    - identify the most acceptable presentations of risk and benefit probabilities
    - explore the acceptability of the new measure, Cat-PROM5, to HCPs
    - identify specific frequently asked questions (FAQs) from cataract surgery
    - explore issues of informed shared decision-making (SDM) for patient counselling.
- To develop a CDA in a FAQ format in which the likelihood of self-reported benefit is set alongside risks of a possible adverse outcome to provide an integrated decision support tool with personalised outcomes prediction.
- To develop a cataract decision quality measure (CDQM) for the patient's cataract surgery decision.

Health economic

- To evaluate the performance of existing and emerging health economic indices [the preference-based measures the EuroQol-5 Dimensions, three-level version (EQ-5D-3L); EuroQol-5 Dimensions, three-level version, with vision 'bolt-on' domain (EQ-5D-3L+VIS); EuroQol-5 Dimensions, five-level version (EQ-5D-5L); and ICEpop CAPability measure for Older people (ICECAP-O)] in people undergoing cataract surgery.
- To investigate how cataract-related visual disability, measured using Cat-PROM5, can be calibrated or mapped against existing and emerging health economic indices of utility.

Work package 4

Quantitative

- To undertake a feasibility study for a future fully powered randomised controlled trial (RCT) of the use of the CDA.
- To estimate the sample size for a possible future fully powered RCT.
- To validate the self-reported outcomes and benefits prediction models.

Qualitative

- To explore how the CDA influences pre-operative SDM.
- To explore how patients and HCPs perceive the CDA in the context of routine care.
- To explore background and specific instances of discordance in which HCPs' and patients' perceptions of outcomes were at odds.

Health economic

- To estimate the implementation costs and potential savings of the use of the CDA.

Methods

Work package 1

Development of Cat-PROM5

Under the construct 'visual difficulty due to cataract', 21 candidate questions were harvested from two published questionnaires for administration to pre- and post-operative patients at four participating NHS centres: Bristol, Gloucestershire, Torbay and Brighton. Three iterative cycles (patients, $n = 200$, $n = 316$ and $n = 306$, respectively) of questionnaire administration, analysis (Rasch, factor analysis), item reduction and validation (precision, test–retest, responsiveness, discrimination, convergent validity) produced the final five-item set that was psychometrically and qualitatively compared in a head-to-head study with the existing, 'best of class', longer, 9-item questionnaire.

Work package 2

Models for adverse outcomes, the very elderly and refractive outcome

Three separate multicentre data extracts were obtained from the National Ophthalmology Database (NOD). The initial extract included $\approx$ 180,000 cataract surgery records, the second $\approx$ 600,000 and the third $\approx$ 1M operation records. Based on the first extract, two key cataract surgery adverse outcomes were modelled by logistic regression: operative posterior capsular rupture (PCR) of the lens and visual acuity (VA) loss in the surgical eye. Based on the second extract, updated models were derived, assessing stability of the PCR model through time and producing specific outcomes for the subgroup of patients aged $\geq$ 90 years. Based on the third extract, indicators of post-operative refractive outcome (spectacle requirement) were generated using a complex-numbers approach.

Work package 3

Quantitative: predictor models of self-reported outcomes

A cohort study with a target sample of 1500 people undergoing cataract surgery in Bristol and Gloucestershire was undertaken to phenotype participants for identification of pre-operative indicators of post-operative outcome. Logistic regression models were developed for both the self-reported Cat-PROM5 post-operative outcome and improvement from pre-operative baseline, each based on pre-operative parameters.

Qualitative: cataract surgery patient information, decision-making, a cataract decision aid and a cataract decision quality measure

Two focus groups and 15 semistructured interviews investigated patient and clinician views on aspects of cataract surgery decision-making at two centres.

The International Patient Decision Aid Standards Collaboration Checklist for the development and quality assessment of patient decision aids was used to guide the development of the CDA using an iterative, collaborative, multistage process, involving a user reference group of 16 key stakeholders and the Patient Advisory Group of five patients, followed by qualitative user testing interviews with a further 20 patients and six clinicians. A CDQM was developed as a trial outcome, drawing on experience from other clinical areas.

Health economic: performance of health utilities and calibration of Cat-PROM5

The Cat-PROM5 and ICECAP-O data were collected from 1181 cohort study participants, with collection of the other three health economic utilities (the EQ-5D-3L, EQ-5D-3L+VIS and EQ-5D-5L) on a 1 : 1 : 1 random allocation basis. Descriptive statistics, linear models and adjusted limited dependent variable mixture models were produced to calibrate utilities with Cat-PROM5. Separate models were estimated for pre- and post-operative Cat-PROM5 completions.

Work package 4

Quantitative: feasibility of a cataract decision aid randomised controlled trial

A two-arm feasibility RCT with a target sample of 40 participants was undertaken, with the CDQM being the primary outcome. Data from participants were used to validate the Cat-PROM5 benefits prediction models, derived in WP3, by comparing model predictions with self-reported parameters.

Qualitative: cataract decision aid, shared decision-making and mismatching outcomes

Perceptions of the intervention were investigated through analysis of anonymised recordings of 42 consultations in the feasibility trial, augmented by interviews with 15 patients and six clinicians.

Mismatching or discordant perceptions of outcome between patients and clinicians were investigated through thematic analysis of interviews with seven patients and nine HCPs.

Health economic

The additional resources incurred from implementation of the CDA compared with standard care in the feasibility trial were assessed based on appointment time costs obtained from the Personal Social Services Research Unit (PSSRU) and the cost per minute of clinician time.

Qualitative: immediately sequential bilateral cataract surgery

A thematic analysis of a meeting of 29 stakeholders exploring the ethical perspectives of immediately sequential bilateral cataract surgery (both eyes at 'one sitting') was undertaken.

Results

Work package 1: Cat-PROM5 performance

A brief, psychometrically robust questionnaire was developed that performed as well as, or better than, the previous, 'best-of-class', longer nine-item alternative. The Cat-PROM5 questionnaire has excellent reliability (Rasch 0.9, person separation 2.98, low differential item functioning, Cronbach alpha 0.89), validity (strong correlation with existing measure, $R = 0.85$), repeatability (Rasch scale intraclass correlation coefficient 0.89) and responsiveness to surgery (baseline Cohen delta −1.45); it is unidimensional (infit–outfit 0.84–1.14, residual eigenvalues ≤ 1.5) and flexible, allowing patients to map their personal visual difficulties to the questions. With only five questions, it is sufficiently brief to make it feasible to implement in routine, high-volume cataract surgical services.

Work package 2: outcome models

Based on the initial anonymised data extract of 180,000 operations, logistic regression models for adverse outcomes had reasonable fit and were broadly similar to those we previously published (*C*-statistic for PCR 0.64; VA loss 0.71).

For PCR model stability, logistic regression analyses using an updated sample of 600,000 operations (*C*-statistics approximately 0.60) over a 10-year period from 2005 to 2014 indicated stability from 2005 to 2011; 2012 was an atypical year, and 2013 and 2014 were comparable.

The outcomes of 25,856 cataract operations undertaken between 2000 and 2014 in 19,166 people aged ≥ 90 years were analysed separately. PCR occurred in 2.7% of these operations. Post-operative VA was available for 61.8% of eyes, with VA being good enough to drive (6/12) in 74.4% overall, and reaching this level in 84.7% for those without visually significant comorbidity.

A refractive outcome analysis using complex numbers was undertaken on a further updated sample of 1,070,601 operations, with a refraction result available for 491,414 of these. Ocular comorbidities did not impact the refractive outcome to a clinically important extent, but the complex-numbers methodology revealed a greater spread of refractive outcomes than expected.

Work package 3: benefits prediction models, cataract decision aid presentation and content, and health economic utilities performance and mapping

The regression models for the Cat-PROM5 post-operative final outcome achieved moderate fit, with an R^2 of 29.1%; for improvement from pre to post operation the model had an R^2 of 31.2%. The models comprise data items that are readily accessible in the context of patient care.

The patient-preferred risk and benefit information presentation was '*n* out of 100 individuals' affected. Despite SDM being performed variably, Cat-PROM5 was generally viewed as being positive for SDM. Concerns were expressed regarding the clinician time needed.

These insights informed the iterative development of the CDA intervention by the user reference group of professionals and patients. Based on the modelling, personalised risk and benefit information was included for adverse outcomes and self-reported benefit. The prototype CDA was further refined by testing the usability, acceptability, utility and expected impact with patients and clinicians.

For health economic utilities performance, the EQ-5D-3L and EQ-5D-5L did not perform well across almost every measure of validity and responsiveness and had the largest ceiling effects. The EQ-5D-3L+VIS had a lower ceiling effect and better convergent validity with Cat-PROM5. The ICECAP-O also had a low ceiling effect, with some evidence of convergent validity with Cat-PROM5.

For health economic calibration/mapping, the adjusted limited dependent variable mixture models dominated linear models on all criteria. Separate pre- and post-mixture models offered good to excellent fit. Three component models, including sex, age and diabetic status, had superior performance (EQ-5D-5L and ICECAP-O root-mean-square errors 0.10–0.16).

Work package 4: randomised controlled trial feasibility, perceptions and costs of the cataract decision aid for shared decision-making, discordant outcomes and bilateral surgery

Of the 145 potentially eligible patients for the RCT feasibility study, 47 were recruited and attended an initial visit. Of these, one withdrew and three were clinically ineligible for surgery. A total of 43 patients were randomised, one of whom subsequently became clinically ineligible, leaving 42 patients across three centres. At the baseline visit, two patients failed to attend. Of the 40 patients who were followed up post operation, 15 participated in the qualitative substudy interviews.

Sample sizes for a fully powered trial were estimated. For independent groups, a small effect size (0.2 standard deviations) would be detectable at 80% power with 800 participants (400 per group), and a medium effect size (0.5 standard deviations) at 90% power with 200 participants (100 per group).

Regarding the choice of prediction model for a future trial, the performance of the prediction model for the final Cat-PROM5 post-operative outcome was superior to the model for pre- to post-operative change in score and would be the preferable model for a future trial.

Observer OPTION 5 Scores revealed clinicians' use of the CDA with patients resulted in more SDM behaviours. However, the key SDM tasks of introducing the choice and eliciting patient's preferences were not always carried out. Many patients had already decided that they wanted the surgery and consultants did not always perceive the choices of 'surgery, delay or decline' as useful. The CDA was effective at providing information to patients about their options, including their personalised risk, but did little to support the introduction of choice or elicitation of preferences. Overall, clinicians felt that, with some changes, the CDA could be integrated into routine clinical settings and form part of a larger trial.

As expected, the identification of patients with discordant outcomes was difficult as these are uncommon events. However, interviews with seven patients and nine HCPs revealed some insights. In most patients' experience, discordance was the result of unexpected changes in visual ability after surgery, highlighting the nuanced and multidimensional 'lived experience' of vision. Factors linked to medical practice were primarily the technologies used. Clinicians and patients believed there was a need for a more personalised approach to SDM on lens choice and refractive aims, and to address patient preferences and expectations and realign these with a more realistic understanding of the potential outcome. The barriers to changing practice included established ways of working and available time for in-depth personalised conversations with patients.

Based on the time taken for consultations in the two arms and additional data collected for the intervention arm, it was possible to collect relevant information to inform a costs analysis.

The pivotal issue under consideration in immediately sequential bilateral cataract surgery is the very low, but unquantifiable, risk of bilateral blindness from surgery with complications if undertaken on 'both eyes at the same sitting', versus patient convenience and service efficiency. Three overarching themes relating to the pros and cons of this were identified and divided into eight subthemes. The themes included beneficence and non-maleficence, autonomy, and distributive justice. The stakeholders concluded that a bilateral procedure was an ethical undertaking, provided patient autonomy was appropriately considered.

Conclusions

- A brief, NHS-implementable, psychometrically robust cataract patient-reported outcome measure (PROM), named Cat-PROM5, was developed to capture visual difficulty due to cataracts and relief through surgery.
- Indicators of cataract surgery adverse outcomes and self-reported benefits were identified, statistically modelled and validated.
- A CDA was developed and refined.
- Health economic work evaluated the performance of established and emerging utilities in cataract surgery and these utilities were mapped to the Cat-PROM5 instrument.
- The feasibility RCT indicated that a future, medium-sized trial would be feasible, with minor refinements of instrumentation.
- Qualitative investigation of discordant or mismatching outcomes highlighted themes relating to patient expectations of surgery and lack of available clinician time for full explanations of the visual changes following surgery.

Implications for clinical practice and services

- Implementable instrumentation for structured measurement of the patient's view of their visual difficulty for both pre-operative assessment and post-operative outcome assessment was developed and is available for use in clinical services.
- Better communication between clinical staff and patients underpins patients having more realistic expectations of surgery.
- Utilising patient-centred metrics could facilitate improved SDM, with clinical tools for individualised estimates of likely self-reported benefits and adverse outcomes enhancing discussion and informing consent.
- The Cataract National Audit has piloted the use of Cat-PROM5 as a patient-focused outcome and intends to develop this further, thus incorporating the patient's voice in outcomes reporting. In the interests of gathering Cat-PROM5 data, both of the specialty-specific ophthalmology electronic medical record system providers of the NHS are developing enhanced functionality for collection of the required data.
- Acceptably low rates of both adverse surgical events and adverse visual outcomes have been found in the very elderly.
- Where there are surgical backlogs arising from the COVID-19 pandemic, we understand that:
    - A number of services are using Cat-PROM5 to prioritise early surgery for those whose self-reported vision is worst affected.
    - The question of operating on both eyes at a single sitting has taken on fresh relevance.

Research recommendations

- A fully powered RCT of the CDA with personalised risk and potential benefit estimates would clarify its potential role in routine care (subject to further refinements of the CDQM outcome measure and earlier use of the intervention in the patient pathway).
- Regular review and update of the risk models for adverse outcomes would ensure currency as these are used to adjust centre and surgeon results for case complexity in national audits.
- The Cat-PROM5 prediction models would benefit from further validation to better understand their performance.
- The technical precision of complex-numbers analysis of the refractive outcome invites opportunities to investigate causes of the spread of refractive outcomes with improvements in the achievement of post-operative spectacle-free vision in mind.
- Further research is needed to clarify the role of surgery on 'both eyes at a single sitting' in terms of safety. Damage to the vision of or even blindness in both eyes owing to, for example, contaminated fluids or infection is a potentially devastating outcome that could follow such bilateral surgery.

Trial registration

This trial is registered as ISRCTN11309852.

Ethics statement

Ethics approval was obtained for all relevant sections of this report.

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