# Reducing the carbon footprint of cataract surgery: co-creating solutions with a departmental Delphi process

Jonathan Malcolm[1], Amy Dodd[1], Mohammad Shaikh[1], Andrew Cassels-Brown[1], John C Buchan[1,2,3]

1. Leeds Teaching Hospitals NHS Trust, Beckett Street, Leeds, LS9 7TF
2. International Centre for Eye Health, London School of Hygiene and Tropical Medicine, London, WC1E 7HT
3. Royal College of Ophthalmologists' National Ophthalmology Database, 18 Stephenson Way, London, NW1 2HD

**Corresponding author**

Jonathan Malcolm

Postal address: Leeds Teaching Hospitals NHS Trust, Beckett Street, Leeds, LS9 7TF

Telephone number: +44 (0) 113 2433144

E-mail address: jonathanpmalcolm@gmail.com

**Running title**

Designing sustainable services with a Delphi process

**Abstract**

Background: Climate change is arguably the greatest threat to global health of the 21st century. Although cataract surgery is a major contributor to global greenhouse gas emissions, recent literature review~~s have~~ identified a paucity of evidence-based strategies for improving the environmental impact of cataract services. Our study aimed to assess the effectiveness of a departmental Delphi process for improving cataract services' environmental sustainability.

Methods: All members of ophthalmology theatre teams in a UK teaching hospital were invited to participate in a three-stage Delphi process. Team members were surveyed for suggestions for reducing the department's environmental impact. Suggested interventions were refined during a plenary face-to-face discussion and ranked. The highest ranked interventions were combined into a mutually agreed action plan. Data on the economic and environmental cost of cataract services was collected prior to and six months after the Delphi process using the *Eyefficiency* mobile application.

Results: Twenty-three interventions were suggested by a range of staff cadres. Interventions were ranked by 24 team members. The 2nd, 4th, 5th, 8th and 11th ranked interventions were combined into an "Eco-packs" project in collaboration with suppliers (Bausch + Lomb), saving 675kg of waste and 350kg of $CO_2$ equivalent annually. ~~A carbon equivalent figure of 67.40kgCO2 per cataract operation was established.~~

Conclusions: The Delphi process is an effective method for provoking departmental engagement with the sustainability agenda that we would encourage all ophthalmology departments to consider utilizing. The baseline *per case* $CO_2$ equivalent measured in our department was reproducible and could serve as a maximum benchmark to be improved upon.

**Introduction**

Climate change is considered one of the biggest threats to global health of the 21st century (1). Despite decades of evidence indicating that greenhouse gas emissions are driving global warming, consumption of fossil fuels continues to rise worldwide (2).

Health care is one of the leading contributors to climate change, accounting for around 4-5% of global greenhouse gas (GHG) emissions (3,4). The United Kingdom National Health Service (NHS) alone produces approximately 25 megatons of carbon dioxide equivalent (CO2e) annually (2021 estimate) (5). In response to the climate crisis, the NHS has set the ambitious goal of becoming the world's first 'net zero' carbon emission national health service by 2040 (6).

Ophthalmology is one of the highest volume specialities. In 2018/19, ophthalmic services were responsible for 8.1% of NHS hospital outpatient visits and cataract surgery was the most performed operation in the UK (7,8). Since operating theatres have been identified as one of the most carbon-intensive components of healthcare, cataract services can be expected to contribute substantially to the NHS's carbon footprint (9,10).

As the UK population ages and patient demographics change, demand for cataract surgery is forecast to grow 52% in the 20 year period up to 2035 (11). It is likely that as eye care provision increases to accommodate the rising demand, so will greenhouse gas emissions.

Mitigating the environmental impact of ophthalmic service expansion and remaining on trajectory towards ‘a net zero NHS’ necessitates strategic service redesign (12). However, recent literature review~~s have~~ identified ~~that there is~~ a lack of evidence in support of strategies for developing more environmentally sustainable cataract services (12).

The Delphi Process is an established method of systematically identifying solutions to problems that lack clear quantitative answers in the current evidence base by generating a consensus of expert opinion (13). Delphi’s role within service development is growing, including its use for prioritising responses to global ophthalmic health concerns (14–17). Our study aimed to use a three-stage Delphi process to determine possible solutions to the growing need for environmentally sustainable cataract services in the NHS. We opted for the Delphi approach to facilitate co-creation and thereby promote ownership of the interventions that were collaboratively developed.

To assess the effectiveness of using a departmental Delphi process to improve the environmental sustainability of cataract services, data was collected on the economic and environmental cost per case of cataract surgery prior to and six months after conducting the Delphi process. Data was collected using the *Eyefficiency* mobile application, which has been developed and used internationally to evaluate the sustainability of cataract surgical services (18–20). This study was undertaken in Leeds Teaching Hospitals NHS Trust, UK, but the Eyefficiency output data may provide potential benchmarking data for eye care units adopting this tool, and the Delphi process may serve as a model for other departments looking to reduce their ophthalmic surgery associated GHG emissions.

## Methods

The methodology for using the *Eyefficiency* mobile application is presented in detail elsewhere (18,19). The first round of *Eyefficiency* data collection was undertaken prior to the Delphi process to establish a baseline, and a second round of data collection was scheduled six months after the Delphi process. Each round of *Eyefficiency* data collection involved collecting the following information: background data regarding the theatre list and the unit (i.e., the number of beds, how long the list is intended to last, staff present at the operating list, minutes to transfer from the ward to theatre and number of equipment trolleys set up in advance), the name of the operation being performed, the experience of the surgeon performing the operation, complications that occurred during the operation, weight of the waste produced during the operation and the time elapsed between important surgical landmarks (i.e., drape on, knife to eye, incision closed, drape off and patient leaves theatre). Descriptive summary statistics are reported for surgical timings, waste produced, and $CO_2e$ produced per cataract surgery performed.

An iterative three-stage Delphi process was used to identify and prioritise strategies for minimizing the environmental impact of cataract surgery. All members of the ophthalmology theatre teams involved in cataract surgery were invited to participate in the process, including surgeons of all grades, operating department practitioners, health care assistants, theatre- and ward-based nursing staff and theatre managers.

The first stage involved sending an email survey containing open-ended questions to all cadres of staff. The survey asked delegates to suggest possible departmental strategies for reducing the negative environmental impact of cataract surgery. Responses to the survey were then de-duplicated, anonymised, thematically organised, and coalesced into a list of possible interventions by the process coordinator (JB).

Second, all cadres of staff were invited to a face-to-face plenary discussion moderated by the process coordinator to discuss each of the proposed ideas. By consensus, the list of suggested interventions was refined, and impractical suggestions were discarded.

Third, the resultant list of interventions was emailed to all team members, asking them to rank each suggestion in order of preference. Delegates allocated 1 point to the least preferable intervention, 2 points to the second least preferable intervention, 3 points to the third least preferable intervention, and so on until all suggested interventions were allocated points. The sum of points allocated to each intervention was then calculated, and the interventions were ranked in order of popularity.

The results of the ranking process were disseminated to team members at a subsequent face-to-face meeting, during which the higher scoring candidate interventions were discussed, and an action plan mutually agreed.

Service evaluations and quality improvement processes ~~constituting audits~~ of this type are exempt from ethical approval under UK NHS Health Research Authority guidance (21). The study was conducted in accordance with the declaration of Helsinki and the UK's Data Protection Act.

**Results**

Responses to the initial email survey generated 23 discrete interventions for reducing the negative environmental impact of cataract surgery. Suggestions were organised into the themes, "reduce", "reuse", "recycle", and "increase efficiency of patient flow in theatre". During the plenary discussion, the list of suggestions was refined to 15 possible interventions by removing impractical suggestions and combining similar suggestions (table 1). The list of interventions was then scored and ranked by 24 respondents, including five consultant ophthalmologists, seven ophthalmology trainees, nine members of theatre and ward nursing staff, two health care assistants and one senior nurse (table 2).

During the final face-to-face session, higher ranked ideas were discussed. The $2^{nd}$, $4^{th}$, $5^{th}$, $8^{th}$, and $11^{th}$ ranked items on the intervention list were combined into an "Eco-packs" project. Team members were assigned to this project, which was carried out in collaboration with suppliers (Bausch + Lomb, Surrey, England). Disposable phacoemulsification packs that contain only the essential equipment required for cataract surgery were designed to reduce waste sent to landfill. Designing the new "Eco-Packs" involved consultation with surgeons and scrub teams regarding which disposable items are often unused in current ~~disposable~~ phacoemulsification packs and opportunities to reduce consumption. The phacoemulsification packs (figure 1a) used routinely weighed 1.05kg.

Items shown in figure 1b were removed to form the newly designed “Eco-packs”, which weighed 0.915kg, saving 0.135kg of waste per cataract surgery performed. Items included in the Eco-packs were: (reusable) microscope handles, notched forceps, mushroom/chopper, phaco handpiece, drape scissors, swab forceps, capsulorhexis forceps, Kuglen lens dialler, (disposable) swabs and gallipot for povidone iodine, adhesive surgical drape, phaco touchscreen cover, cassette/tubing, keratome (used for all incisions), silicone tipped irrigation/aspiration handpiece, 2.5ml syringe, 5ml and 1ml syringes for cefuroxime, phaco needle, balanced salt solution, prefilled viscoelastic syringe, dexamethasone 0.1% minim. Some items were equivocally necessary (eg Kuglen lens dialler could be omitted, and dialling performed with the mushroom) but the pack represent a compromise between the aspiration to reduce and the necessity of being acceptable to all surgeons in a training environment. Since approximately 5,000 cataract operations are performed annually in the host institution’s Ophthalmology Department, with all surgeons swapped over to adopt the new “Eco-packs” locally, it is estimated that 675kg of manufactured disposables and incinerated-waste management are being saved each year.

The 3rd, 6th and 12th ranked items on the intervention list targeted improved theatre time management. An application was made to the Clinical Governance committee to stop counting swabs and instruments in theatre and to administer iodine drops outside of theatre. Permission was denied for all three by hospital management because of local trust policies.

The first round of *Eyefficiency* data collection (n=40 cataract cases with full data capture) estimated that 67.4538kg CO2e per case of cataract surgery was generated (table 3).

(Initially, 45 cases were observed as part of the first round of CO2e data collection. However, because of incorrect data capture entered on the *Eyefficiency* application in the early stages of the study, the first 5 cases were omitted from the total calculated CO2e per case.)

The second round of *Eyefficiency* data collection (n=40 cases) produced an estimate of 67.42kg CO2e per case of cataract surgery (table 3). The intention had been to realise service changes prior to the second round of *Eyefficiency* data collection. However, because of the need to use up the existing stock of preprepared disposable phacoemulsification packs, the newly designed "Eco-Packs" were not yet being routinely used locally at the time of the second round of data collection. The second round of *Eyefficiency* data therefore serves to demonstrate the repeatability of the measurements and increases the sample size, generating an estimate of 67.440kg CO2e over the two sampling periods (n=80 cases).

The very similar CO2e estimates for the two rounds of *Eyefficiency* data collection is despite around half of the observed cases in the second round being consultant delivered, whereas all observed cases in the first round were undertaken by senior trainees (table 3).

It took approximately one year after the start of the Delphi process for the "Eco-Packs" to be used as a standard in the department. A third repeated audit cycle with *Eyefficiency* data collection was prevented by the Covid-19 related disruptingon of theatre practices to an extent that rendered comparison invalid. For example, procurement costs, theatre flow and infection prevention practices dramatically changed during the pandemic, which would likely confound any comparisons made between pre- and post-pandemic *Eyefficiency* data.

The expected CO2e and waste produced following the introduction of the “Eco-packs” was therefore estimated by modelling a third audit cycle in which COVID-19 related services changes had not occurred. Since the only variable expected to change following the introduction of the “Eco-packs” would be the weight of the waste, a reasonable estimate of the CO2e and waste produced could be calculated on *Eyefficiency* by utilizing the data collected for the second audit cycle but with a 0.135kg reduction in the mean waste produced per case to account for the lighter weight of the “Eco-packs”. Using this method, a CO2e of 67.35kg per case following the introduction of the “Eco-packs” was estimated, which compared to the second audit cycle is a reduction in CO2e of 0.7kg per case or 350kg over the 5,000 operations performed annually at the trust (table 3).

**Discussion**

Climate change may present the biggest challenge for global health of the 21st century (22). The opportunities for the health care sector to reduce its negative environmental impact come from the highest volume services and the most resource-intensive aspects of those services. Cataract surgery would, therefore, be a priority target for improvement. However, literature reviews have identified a lack of evidence-base for interventions aiming to improve cataract services’ environmental sustainability (12).

This study presents a methodology that could be employed by any cataract surgical service provider to identify opportunities to improve the efficiency of resource utilisation and reduce the negative environmental impact of services. To promote longevity of behaviour change, co-creation of the ideas was felt to be important. Strong departmental engagement was seen with the Delphi process; 23 initial ideas were submitted from a full range of staff cadres, and 24 staff members contributed to the ranking process. Although there is no evidence base to support the belief that co-creation of ideas will lead to more effective implementation of those ideas, it can be observed that the interventions within the control of the ophthalmic theatre team were actioned (23). Whereas, interventions, such as exemption from counting swabs and instruments on cataract surgical lists, which required wider managerial support from the hospital, were not possible.

The ideas generated have resulted in the successful adoption of "Eco-Packs" in the department, such that these are now the standard cataract surgical packs used by all surgeons. Although this has resulted in a modest reduction in the carbon footprint of cataract surgery, it is impossible to extricate the environmental impact reduction agenda from the theatre time management efficiency agenda. Increasing the flow of patients on cataract surgical lists means that the same resources and fixed costs (both financial and environmental), such as the building and staff costs, are spread over a greater number of patients, hence the *per case* carbon footprint is reduced. However, in a teaching hospital environment where every operating list involves trainees, there is usually a direct trade-off between the number of cases completed and the training opportunities created.

The *Eyefficiency* application brings together the evaluation of theatre utilisation of financial resources, environmental resources and theatre time. Efficiency savings with increased surgical throughput offers gains for all three resource areas, as well as improving outcomes for patients because of the relationship between higher surgical volumes and lower complication rates (24). Despite the inclusion of operating lists in which consultant surgeons completed 21/40 cases in the second round of data collection, the reduction in mean case to case duration (from 37 to 33 minutes) achieved by these inclusions was insufficient to see extra cases added to lists. Only when time savings permit increased case numbers on operating lists are environmental savings realised. It may have been that service lists delivered solely by consultant surgeons with no trainee presence would have been sufficiently efficient to add extra cases. The constraints imposed upon time efficiencies by the necessity to train junior surgeons led us to conclude that there is an environmental cost of training that has not previously been considered. Interventions that have been proven to shorten surgical learning curves, such as the use of simulation training, may therefore help improve the sustainability of cataract services (25,26).

We would encourage all cataract surgical providers to consider utilizing a Delphi process to provoke engagement with the sustainability agenda and identify interventions that might reduce inefficiencies in theatre resource utilisation. The *Eyefficiency* application is a powerful tool with which efficiency savings achieved by interventions co-created via the Delphi process can be quantified and cyclical audits systematised. Our study reports *Eyefficiency* output data from a tertiary centre in the UK, which may serve as useful benchmarking data for other ophthalmology departments looking to adopt this tool.

The gains that may be achieved by eye care units utilizing the Delphi process and *Eyefficiency* can be expected to be small compared to the magnitude of the aspiration of the NHS to reach net zero carbon emissions by 2040. However, given the frequency with which cataract surgery is performed, even small gains may represent a worthwhile contribution towards achieving a net zero NHS.

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Data availability: The datasets generated during the current study are available from the corresponding author on reasonable request.

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**Figure Legends**

Figure 1. A) Phacoemulsification trolley set-up prior to the Delphi process. B) Items removed after the Delphi process: arm covers, large kidney bowl, spear swabs, eye shield and packaging, 30-degree stab knife, phacoemulsification machine tray cover and small refuse bag.

**Summary Box**

What was known before:

- Cataract services are likely a major contributor to global greenhouse gas emissions.
- Significant strategic service redesign will be needed to develop environmentally sustainable cataract services.

What this study adds:

- The Delphi process is an effective strategy for facilitating departmental co-creation of ideas to improve the environmental sustainability of cataract services.
- The *Eyefficiency* application can be used to quantify gains achieved by the Delphi process and systematically audit interventions aiming to reduce the carbon footprint of cataract surgery.