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Letter to the Editor

One step forward to sustainability: The carbon footprint of cataract surgery in Australia

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Climate change is the greatest public health threat of our time and as healthcare professionals we are compelled to act urgently through mitigating carbon emissions. Globally, healthcare accounts for a significant carbon footprint.[1] Within ophthalmology, cataract surgery represents the single greatest opportunity for reducing emissions due to its high surgical load and use of disposable goods.[2] We estimate the carbon footprint of cataract surgery at a major tertiary hospital in Australia (Royal Melbourne Hospital, RMH), and recommend steps toward improving sustainability.

A prospective case series of 31 cataract surgeries (phacoemulsification) was conducted with the Royal Melbourne Hospital Human Research Ethics Committee approval. The Eyefficiency application, an established auditing tool based on a hybrid lifecycle analysis methodology,[3] was used to estimate the efficiency, cost, and environmental impact (Table 1, with published international data shown for comparison).

Table 1: Efficiency, cost, and greenhouse gas emissions of cataract surgery in Australia with comparison to nine international sites from the Eyefficiency study[3]

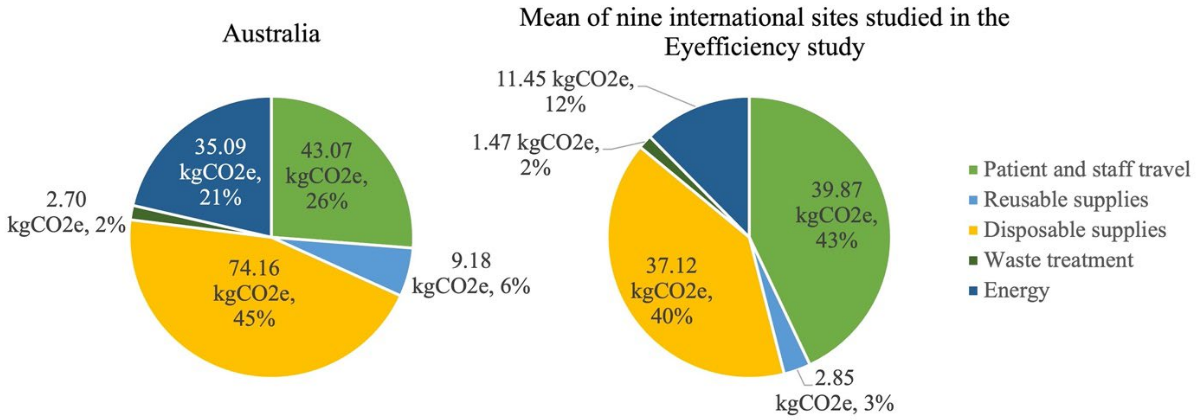
Country	**Australia**	**New Zealand**	**UK**	**Hungary**	**Chile**	**South Africa**	**Mexico, 1**	**Mexico, 2**	**India**	**Swaziland**
Total cases: monitored/conducted annually (% monitored)	31/444 (7)	33/530 (6)	40/4786 (1)	37/1600 (2)	50/1000 (5)	28/2000 (1)	30/3485 (1)	26/807 (3)	53/14543 (0)	10/147 (7)
Floor area in square metres of operating theatre space/ square metres of total hospital area)	35/127799	35/425	35/100000	35/100000	35/6940	35/8600	35/3000	35/1700	35/21897	102/7192
Renewable energy? (annual %)	No	No	No	No	No	No	No	No	Yes (0.2)	No
Regular diesel use? (annual %)	No	No	No	No	No	No	No	No	No	No
Dual bed system?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Average days per week operating on cataracts	2	3	5	4	2	5	4	5	6	2
Average preoperative appointments	1.4	1	2	1	5	1	2	2	1	2
Average postoperative appointments	1	1	1	2	3	2	3	3	1	3
Total number of staff present on the day of surgery	8	6	9	9	6	5	6	7	10	6
Cases per hour	1.2	1.7	1.94	3.61	4.48	2.01	2.92	1.51	4.25	3.14
Case-to-case duration: minutes (Standard Deviation [SD])	47.6 (9.0)	35.3 (19.6)	29.9 (16.5)	16.4 (11.5)	13.4 (4.4)	57.5 (28.0)	38.9 (23.3)	70.6 (18.4)	38.1 (39.8)	25.7 (12.6)
Preoperative	17.5	10.35	4.18	1.85	4.45	16.38	16.8	25.69	10.86	7.02
Operating	16.53	13.3	12.05	9.18	6.27	14.54	14.59	22.39	1.94	11.36
Postoperative	3.57	2.43	2.7	1.55	2.02	3.43	3.86	13.05	2.11	1.97
Turnover	14.43	9.22	10.98	3.79	0.65	23.12	3.69	9.51	23.15	5.34
Cost per case: $	830.06	694.8	368.63	484.59	121.3	138.29	282.49	636.34	54.89	115.34
Staff salaries	276.19	105.37	76.29	37.29	23.96	25.61	23.04	41.64	0.97	52.46
Reusable supplies	10.96	8.39	28.92	0.35	4	4.92	3.06	0.21	0.16	0.52
Disposable supplies	532.26	577.48	255.52	442.61	87.27	105.14	251.69	588.74	53.45	44.12
Waste treatment	0.47	0	2.17	0.82	2.4	1.32	1.43	4.28	0.07	0.89

Energy	9.9	3.57	5.72	3.53	3.67	1.29	3.25	1.5	0.24	17.38
Greenhouse gas emissions per case: kilograms of carbon dioxide equivalent **(kgCO2e)**	164	123	67	130	86	55	114	121	41	98
Patient and staff travel	43.07	32.62	19.2	50.1	62.39	20.9	73.2	34.48	28.8	37.16
Reusable supplies	9.18	3.39	2.55	3.59	1.68	4.7	2.44	1.22	3.16	2.91
Disposable supplies	74.16	81.25	35.95	61.84	12.21	14.45	34.45	80.59	7.32	6.03
Waste treatment	2.7	0.65	2.09	0.78	2.29	1.24	1.33	3.99	0.07	0.82
Energy	35.09	4.84	7.67	13.4	7.32	13.33	2.98	0.64	1.43	51.45
Number of kilometres driving in petrol car that one cataract surgery is equivalent to	650	494	271	522	345	220	460	487	164	396
Garbage per case: kilograms (kg)	2.11	0.33	4.27	0.71	1.32	1.06	0.67	2.23	0.87	0.19

The mean cost of cataract surgery was $830. Disposable supplies accounted for the largest proportion ($532.26, 64%) of cost. The most expensive items were the phacoemulsification custom pack and intraocular lens. Costs in the current study were calculated in August 2022 and are stated in Australian dollars. For comparison, costs of cataract surgery in the nine international sites, which were originally calculated in 2019, were converted from British pounds to Australian dollars using the average 2019 exchange rate.

A single cataract surgery generated 164 kilograms of carbon dioxide equivalent (kgCO2e) of carbon emissions and 2.11 kilograms (kg) of garbage. Disposable supplies were the greatest source of carbon emissions (74.16 kgCO2e, 45.2%), followed by patient and staff travel (43.07 kgCO2e, 26.3%), and electricity use (35.09 kgCO2e, 21.4%) (Figure 1). Of the emissions pertaining to disposables, 70.48 kgCO2e was attributable to the custom pack and intraocular lens, and 3.68 kgCO2e from other products such as intracameral antibiotics. Regarding travel emissions, the mean distance travelled by patients was 37.5 kilometres (km) and by staff was 14.8 km, via petrol car, emitting 40.7 kgCO2e and 2.4 kgCO2e respectively. Surgical waste by mass comprised of irrigation fluid, phacoemulsification cassette and tubing (40%), unrecyclable wraps/drapes (20%), gowns and gloves (15%), unrecyclable trays, gauze, and syringes (15%), and plastic packaging (10%). Paper, recyclable plastics, and sterilisation wraps were all recycled.

Figure 1: Causes of carbon emissions in cataract surgery in Australia (left), compared to international sites (right).[3]



We report a carbon footprint of 164 kgCO2e per cataract surgery in Australia. This is equivalent to driving 660 km in a car or burning 70 litres of petrol. Our footprint is comparable to other developed countries such as the United Kingdom (182 kgCO2e)[4] and New Zealand (152 kgCO2e).[2] However, some countries report a much lower emission, for example, 6 kgCO2e in India.[5] In India, this was achieved because almost all equipment was re-used (e.g. disposing of gloves after 10 cases, replacing gowns and phacoemulsification tubing once daily) and most of the waste was recycled locally. This highlights how different surgical practices can generate vastly different emissions.

Disposable goods were the greatest source of emissions in our study, accounting for 45.2% of the total carbon footprint. They also accounted for the greatest cost (64.1%). Therefore, targeting disposable supply use and the procurement process may lead to the most meaningful emission reductions. For example, a good start may be to reduce unnecessary items in the custom pack – we observed multiple syringes, needles and trays were frequently discarded unused.

The second greatest source of emissions was patient travel. Previously, patients were required to attend a separate preoperative appointment for biometry. We estimated that the carbon emissions per case would reduce by 9.25 kgCO2e if this was eliminated (i.e., biometry performed on the same day as the standard clinic appointment), and we have now implemented this change at our hospital.

Electricity use also contributed to significant emissions. This could be reduced by transitioning to renewable energy. At present with the current infrastructure, there is no provision for renewable energy, but our hospital has pledged to transition to more renewable energy use by 2025.

This study had several limitations. Firstly, the Eyefficiency tool uses a hybrid lifecycle analysis approach, including an economic input-output model which allows for price-based estimation of the carbon footprint of certain surgical supplies, given there are no detailed lifecycle analyses of individual products currently available.[3] However, the cost is affected by market factors, and cost reduction for example due to purchasing deals does not reduce the actual emissions. The COVID-19 pandemic has also increased costs due to supply chain issues but not necessarily increased emissions. Secondly, this study was performed in a large tertiary teaching hospital with complex cases and may not be generalisable to private or ophthalmology-specific settings.

This is the first study of the carbon footprint of cataract surgery in Australia, offering a baseline for benchmarking locally and globally. There are significant opportunities for reducing emissions in cataract surgery. Carefully considering the use of disposable goods, reducing patient travel, and transitioning to renewable energy sources are all worthwhile targets. More studies from different cataract surgical settings including the private sector are needed to establish a baseline for future sustainability auditing.

REFERENCES

1. Karliner J SS, Boyd R, Ashby B, Steele K. *Health Care's Climate Footprint: How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action: Healthcare Without Harm.*: ARUP;2019.
2. Latta M, Shaw C, Gale J. The carbon footprint of cataract surgery in Wellington. *N Z Med J.* 2021;134(1541):13-21.
3. Goel H, Wemyss TA, Harris T, et al. Improving productivity, costs and environmental impact in International Eye Health Services: using the 'Eyefficiency' cataract surgical services auditing tool to assess the value of cataract surgical services. *BMJ Open Ophthalmol.* 2021;6(1):e000642.
4. Morris DS, Wright T, Somner JEA, Connor A. The carbon footprint of cataract surgery. *Eye.* 2013;27(4):495-501.
5. Thiel CL, Schehlein E, Ravilla T, et al. Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility. *J Cataract Refract Surg.* 2017;43(11):1391-1398.