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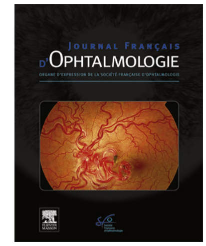

ORIGINAL ARTICLE

The carbon footprint of cataract surgery in a French University Hospital

Le bilan carbone d'une chirurgie de la cataracte dans un hôpital universitaire français

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KEYWORDS
Cataract surgery;
Carbon footprint;
CO_2 equivalent;
Greenhouse gases;
Disposable;
Waste;
Ecoconception;
Reduce;
Reuse;
Recycle;
Life cycle assessment

Summary
Purpose. — To assess the carbon footprint of cataract surgery in a French university hospital.
Setting. — Operating room of Cochin University Hospital, Paris, France.
Design. — Single-center component analysis.
Methods. — One day of surgery was used as a reference. Greenhouse gases (GHG) related to patient and staff transportation were calculated based on the distance travelled and the means of transportation used. The annual consumption of energy (heating and electricity) of our building was converted in kg equivalent of carbon dioxide (CO_2eq), and the principle of proportionality was used to calculate what was used for a single cataract procedure. GHG emissions related to the life cycle assessment (LCA) of the equipment used and the sterilization process were calculated.
Results. — The LCA of disposable items accounted for 59.49 kg (73.32%) of CO_2eq for each procedure. A single procedure generated 2.83 ± 0.10 kg of waste. The average CO_2eq produced by the transportation of the patients to and from our center, adjusted for one procedure, was 7.26 ± 6.90 kg (8.95%) of CO_2eq. The CO_2eq produced by the sterilization of the phacoemulsifier handpiece was 2.12 kg (2.61%). The energy consumption of the building and staff transportation accounted for the remaining CO_2eq emissions, 0.76 kg (0.93%) and 0.08 kg (0.10%) respectively. Altogether, the carbon footprint of one cataract procedure in our center was 81.13 kg CO_2eq — the equivalent of an average car driving 800 km.

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Conclusion. — Our data provide a basis to quantify cataract surgery as a source of GHG and suggests that reductions in emissions can be achieved.

MOTS CLÉS
Chirurgie de la cataracte ;
Empreinte Carbone ;
Équivalent CO_2 ;
Gaz à effet de serre ;
Jetable ;
Déchets ;
Écoconception ;
Réduire ;
Réutiliser ;
Recycler ;
Évaluation du cycle de vie

Résumé
Objectif. — Évaluer le bilan carbone d'une chirurgie de la cataracte dans un hôpital universitaire français.
Méthode. — La quantité d'équivalent CO_2 (CO_2eq) produite par l'activité chirurgicale d'une salle opératoire sur une journée a été mesurée, puis rapportée à une intervention. Les émissions directes liées au transport des patients et du personnel ont été calculées en fonction de la distance parcourue et du moyen de transport utilisé. Les émissions directes liées aux consommations énergétiques annuelles du bâtiment (chauffage, électricité) ont été recueillies puis calculées et ajustées pour une salle opératoire. L'analyse du cycle de vie (ACV) de tout le matériel utilisé et du processus de stérilisation a été réalisée.
Résultats. — L'ACV du matériel à usage unique était responsable de 59,49 kg (73,32 %) de CO_2eq pour chaque intervention. Chaque procédure générait 2,83 ± 0,10 kg de déchets. Le transport des patients produisait en moyenne 7,26 ± 6,90 kg (8,95 %) de CO_2eq. La quantité de CO_2eq produite par la stérilisation d'une pièce à main était de 2,12 kg (2,61 %). Le bâtiment et le transport du personnel étaient responsable respectivement de 0,76 kg (0,93 %) et 0,08 kg (0,10 %) de CO_2eq. Le bilan carbone d'une chirurgie de la cataracte était de 81,13 kg de CO_2eq.
Conclusion. — Cette étude permet de comprendre l'impact écologique de la chirurgie de la cataracte et d'envisager une écoconception de la chirurgie. Une amélioration des pratiques est possible.

Abbreviations and Acronyms

ACV	*analyse du cycle de vie*
CH4	methane
CO_2	carbon dioxide
CO_2eq	equivalent of carbon dioxide
DEFRA	Department for Environment, Food and Rural Affairs
EIO-LCA	economic input-output life cycle assessment
GHG	greenhouse gases
HFCs	hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
LCA	life cycle assessment
N_2O	nitrous oxide
PFCs	perfluorocarbons
SF6	sulphur hexafluoride
TASS	toxic anterior segment syndrome
TSE	transmissible spongiform encephalopathies
UK	United Kingdom
US	United States of America
WHO	World Health Organization

Introduction

The awareness regarding global warming has been increasing over the last four decades [1]. During that period data has accumulated to show that human activity generates greenhouse gases (GHG) that are in part responsible for climate change [2]. Today, global warming is a scientific and political challenge, considered by many as a threat to the planet [3]. Recently, Neukom et al. [4] reported that the past century was the warmest of the last 2000 years in 98% of the globe. In order to lower our GHG emissions, numerous strategies have been adopted in fields such as energy production, transportation, agriculture, housing, etc. [5]. The assessment of the share of the health sector in the generation of GHG is more recent [6—8]. Reducing GHG emissions produced directly and indirectly in relation to any human activity requires first to evaluate its carbon footprint, which is usually expressed in equivalent tons of carbon dioxide (CO_2eq). The health sector, and especially surgery, has a significant carbon footprint [8], which has been estimated to contribute to 7% of national GHG emissions in Australia [6], 3%—4% in England[1] and 9%—10% of GHGs in the US [7]. Health care's climate footprint is equivalent to 4.4% of global net emissions worldwide.[2]

[1] National Health Service Sustainable Development Unit. Carbon update for the health and care sector in England 2015. London: 2016. https://www.sduhealth.org.uk/documents/publications/2016/Carbon_Footprint_summary_NHS_update_2015_final.pdf.
[2] Health care's climate footprint. 2020. https://noharm-uscanada.org/content/global/health-care-climate-footprint-report.

Cataract surgery is one of the most cost-effective and common surgical procedures [9,10]. Cataract surgery induces improvements in visual acuity, which generate considerable benefits in the patients' daily life, while enhancing their mood and social life [11]. It also has been shown that cataract surgery, by improving their vision, reduces the risk of bone fractures in elderly patients and safeguards their autonomy [12]. The improvement of surgical techniques and material has spectacularly reduced the rate of complications including endophthalmitis [13]. While modern cataract surgery has become extremely safe we asked ourselves whether this resulted in an increase in its kg of carbon dioxide (CO_2) emissions [14]. Morris et al. [15] and Thiel et al. [16] reported the carbon footprint of cataract surgery in two countries and their results were highly contrasted. In Wales, one cataract surgery produced 20 times more CO_2eq than in India. The aim of our study was to assess the carbon footprint of cataract surgery in a French university hospital.

Materials and methods

Carbon footprint analysis

Carbon footprint analysis is a method of quantifying GHG emissions related to an activity, e.g. cataract surgery [14,16] This takes into account all GHG defined by the intergovernmental panel on climate change (IPCC) for all physical flows without which the studied activity would not be possible.[3] The Kyoto Protocol defined six main GHG: CO_2, Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6).[3] They can be converted into CO_2eq according to their impact on global warming. In the interest of simplification, the unit CO_2eq is used to express the emission of all the GHG. We applied this method to assess GHG direct and indirect emissions of a cataract procedure performed in our department. Direct emissions were defined as related to the energy required for the transportation of patients and staff to our center, as well as the energy required to operate our facility. Indirect emissions were defined as related to the life cycle of our surgical material and pharmaceuticals products [14]. For this purpose, we used a standardized method of Economic input-output Life Cycle Assessment (EIO-LCA) as a multicriteria tool to globally assess the environmental impact of our activity. This was used to measure the quantifiable effects of the products used for our procedures on the environment, based on the assessment of the physical flows of matter and energy. As previously reported, the stages of a product's life cycle were taken into account for the inventory of GHG emissions from ''cradle to grave'', which corresponded to the addition of the following: extraction of energy and non-energy raw materials necessary for the production, distribution, use, collection and all phases of transport of the product. The EIO-LCA method estimates the GHG emissions resulting from production and distribution of any product, using its cost. Disposal was estimated separately and added to obtain the final LCA.

Data collection

We collected the data in the ophthalmology department of Cochin University Hospital in Paris, France. We used one day of surgery (November 20th, 2018) in a single operating room where 12 uncomplicated cataract procedures were performed as a reference for the staff and patient travel, as well as waste audit. The staff comprised 2 surgeons, who performed 6 procedures each, assisted by a single resident. On the study day, two nurses and one healthcare assistant were dedicated to the cataract procedures. We collected the addresses and the means of transport of the patients and staff to and from the hospital. We calculated the distances using Google Maps (http://www.google.com/maps/) and converted them in kg CO_2eq according to the means of transport (Supplemental table 1).[4]

For each surgical disposable item and each pharmaceutical used during cataract surgery, we recorded the following data: place of manufacture, price, means of transport, storage, and distribution methods. We contacted the pharmaceutical and medical companies when the information regarding their production site wasn't clearly labelled on the packaging of their products. They provided the precise location of the manufacturing and storage sites for each item, as well as their mode and routes of distribution. The calculated travelled distance was the sum of the distance from the last production site to the distribution center and from there to our hospital. The addition of each category of GHG providers (direct and indirect emissions) was done after the conversion in CO_2eq to obtain the total amount of CO_2eq (including patient and staff distance travelled, cost of supply for EIO-LCA, disposal, energy consumption and sterilization process, but excluding our routing analysis because it was already included in the EIO-LCA conversion factor). The GHG emissions related to the sterilization step of our single-use devices were not specifically accounted for. This was included in the global estimate of GHG emissions related to manufacturing, packaging and routing (EIO-LCA).[5] To maintain consistency with ''Bilan Carbone®'' methodology and PAS 2050, we excluded from the analyses the sources of GHG emissions estimated to be inferior to 1% of the total emissions: energy required for construction of the building, energy required for the manufacturing and the delivery to our center of the phacoemulsification machine as well as our surgical microscope. Besides, we neglected the food and beverages consumed by the staff. We also excluded activities related to medical research. Water consumption was not taken into account as it was assumed to be negligible in consideration of CO_2eq, as 1 L of water used produce

[3] Takahiko Hiraishi, Thelma Krug, Kiyoto Tanabe, Nalin Srivastava, Baasansuren Jamsranjav, Maya Fukuda, Tiffany Troxler. Hiraishi: 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol; 2019. https://www.uncclearn.org/sites/default/files/inventory/ipcc20_0_1.pdf.

[4] Greenhouse Gas Balance Resource Center. Centre de ressources sur les bilans de gaz à effet de serre. ADEME — Site Bilan GES. 2019. https://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/choix-categorie.

[5] PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. 2019. http://shop.bsigroup.com/upload/shop/download/pas/pas2050.pdf.

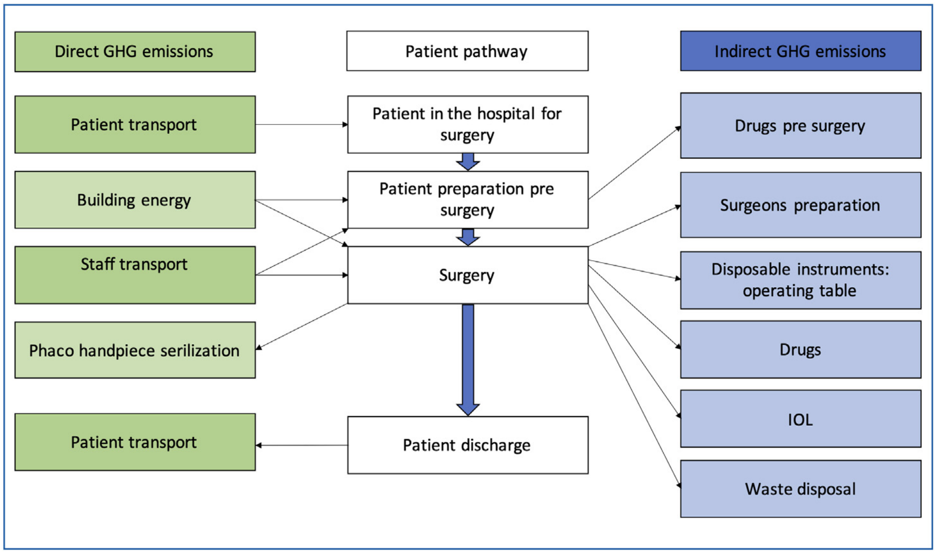

Figure 1. Flowchart of the itemization of direct and indirect greenhouse (GHG) emissions at the different steps of the patient pathway.

0.1 g of CO_2eq.[3,4] We collected the waste related to each procedure and divided it as unregulated or regulated (biohazardous) medical waste. The waste was sorted out and weighed. We calculated the carbon footprint for production and disposal using the weight and composition of each item. We calculated the impact of waste transportation using the distance from the hospital to the center where it was processed. At the time of our study, the waste generated by the procedures was not recycled but destroyed by incineration. There was no negative impact of recycling to be reported.

We converted the annual consumption of energy (electricity and steam) of our building in kg CO_2eq and reported it by square meter per day. It was adjusted to calculate the consumption of a single operating room. Based on the calculations made by our hospital's engineering department we estimated that the energy consumption per square meter of each of our operating room was 1.4 that of the rest of the building. These calculations were made by taking into account the electricity consumption of our operating room's ventilation system.

We estimated the energy required to sterilize the phacoemulsification handpiece — which was the only reusable instrument — to be a fraction of the total energy consumption of the sterilization department, based on the share of ophthalmology in its global activity (Fig. 1).

The estimated sterilization department GHG emissions per year was 40,962 kg of CO_2eq. Twenty percent of their activity were related to ophthalmology and 12.4% were related to the sterilization of the phaco handpiece. We recorded the number of their staff participating in the sterilization of the phacoemulsification handpieces, as well as their addresses and means of transport.

CO_2eq conversion

We applied established emission factors to reconcile the activity data from the different sources to a single unit of measurement for GHG emissions (CO_2eq). The conversion of the data in CO_2eq was done according to the conversion tables of the French ''Bilan Carbone ®'' protocol, the Greenhouse Gas Protocol (GHG Protocol) and the DEFRA's emission factors used in the Publicly Available Specification for the measurement of the GHG emissions from goods and services (PAS2050).[4,5,6] We matched our inputs with the most relevant conversion factors according to the country where the process occurred. We used the ''Bilan Carbone®'' conversion table to match energy the mix of Paris in 2018, the waste treatment in France and the transport in France.[4] We used the ''Bilan Carbone®'' to convert the price (excluding tax) of pharmaceutical products (500 kgCO_2eq/keuro); DEFRA's emission factors (in proportion to the price including tax) for the medical devices production's and transportation's emissions (270 kgCO_2eq/keuro) as ''Bilan Carbone ®'' did not provide any and GHG Protocol to estimate the material transportation around the world (Supplemental table 2).[5,6,7] Emission of CO_2eq related to transport of goods were already included in the EIO-LCA methods. We calculated CO_2eq emission related to transport separately to understand its part in the LCA of each product.

We reported the means and standard deviations for all categories. The study did not directly involve patients and thus did not require approval by an ethics committee.

Results

Table 1 shows the different sources of CO_2 emissions for the day of the study. All the materials other than the

[6] Calculation Tools | Greenhouse Gas Protocol. 2019. https://ghgprotocol.org/calculation-tools.

[7] AEA for the Department of Energy and Climate Change (DECC). 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. 2012. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69554/pb13773-ghg-conversion-factors-2012.pdf.

Table 1 Greenhouse (GHG) gas emissions for cataract surgery in a French hospital.

GHG providers	Sub-category	CO_2eq for one day (kg)	CO_2eq for 1 patient (kg)	% of total
Direct CO_2 emissions				
Transport	Patients ($n = 12$)	87.17	7.26	8.95
	Staff ($n = 6$)	0.96	0.08	0.08
Building	Electricity Steam	9.10	0.75	0.76
Sterilization	Phacoemulsifier handpiece	25.42	2.11	2.61
Indirect CO_2 emissions				
LCA medical devices (MD)	Manufacturing and procurement (including transport)	713.83	59.49	73.32
LCA pharmaceutical products (PP)	Manufacturing and procurement (including transport)	123.48	10.29	12.68
	→ Transport of MD & PP	65.37	5.45	6.71
	Disposal	13.57	1.13	1.39
Total		973.53	81.13	100

phacoemulsifier handpiece used during the surgery were disposables. Their life cycle assessment accounted for 59.49 kg of CO_2eq for each procedure and corresponded to the largest share (73.32%) of the total carbon footprint. The manufacturing and procurement of pharmaceutical products was estimated as 10.29 kg of CO_2eq (12.68% of the total carbon footprint). The distribution of disposable items and pharmaceutical products, from their manufacturing site to our center, accounted for 5.45 kg CO_2eq for each procedure and 6.71% of the total carbon footprint. The disposable items used for each procedure came from 13 different countries and travelled a cumulative distance of 91,412 km (Table 2). On average, the disposable items were manufactured 2856 ± 3544 km [median 1000, range 240—9639] away from our center. Each procedure generated an average of 2.83 ± 0.10 kg of waste. The smallest share of waste [0.17 kg (5.9% of total waste)] was hazardous material, which included blades, needles and disposable surgical instruments. The largest share of waste [2.66 kg (94.1% of total waste)] was unregulated and included surgeons' scrub suites, patient and staff disposable apparel, table drapes, gloves, as well as all packaging. The waste destruction generated 1.13 kg of CO_2eq (5.6% of the total carbon footprint). The average CO_2eq produced by the transportation of patients to and from our center was 7.26 ± 6.90 kg for one procedure, which accounted for the third ranking share (8.95%) of CO_2 emissions. The CO_2eq produced by the sterilization of the phacoemulsifier handpiece was 2.11 kg, which accounted for the fourth ranking share (2.61%) of CO_2 emissions. The energy consumption of the building and staff transportation accounted for the remaining CO_2eq emissions, respectively with 0.76 kg (0.93%) and 0.08 kg (0.10%). Altogether, the carbon footprint of a single cataract surgery procedure in our center was 81.13 kg CO_2eq.

Discussion

To our knowledge, the life cycle assessment of cataract surgery has so far been estimated only in India and in the United Kingdom. The calculated carbon footprint of a cataract procedure in our institution was 81.13 kg of CO_2eq. This carbon footprint was 2.2 times lower than that calculated by Morris et al. for the procedures performed in Wales [15]. Yet, our results suggest that we produced 13.5 times more CO_2eq per procedure than what was calculated by Thiel et al. in India [16]. Were restricted our calculations to the cataract procedure, while Morris et al. analyzed the whole ''cataract process'' including pre- and postoperative visits. Moreover, Morris et al. based their estimates on the entire ophthalmology unit, while we restricted our analyses to the operating room. Our operating room was built in 2017 with modern standards of energy consumption and efficient thermal insulation. Moreover, the production of energy in France generates less CO_2 than in the UK because electricity in France is mostly provided by nuclear plants (0.084 $kgCO_2$/kWh in France versus 0.594 $kgCO_2$/kWh in the UK [15]).[4]

The methods we used to estimate our GHG production were similar to Thiel et al.'s who also restricted their analyses to the cataract procedure itself [16]. Our greater CO_2eq production can be explained by the use of more disposable items. Indeed, in India 250 g of waste were measured for each procedure while we generated 2.83 kg of waste. Moreover, 93 cases per day were performed in a single Indian operating room, as opposed to only 12 cases in our study. As previously reported, the more numerous the cases performed per day in an operating room, the lesser the share of GHG emissions associated with each procedure [16]. All the studies have shown that the procurement of medical devices and

Table 2 Place of manufacture of the medical and pharmaceutical items used for one cataract procedure.

Material	Weight (g)[a]	Country or state of production	City of production	Estimated travelled distance (km)	Price for one surgery (euros)
Disinfection tray	22	Bulgaria	—	2462	0.28
Screw syringe 5 cm^3	1	France	Le Pont de Claix	575	0.08
Betadine single dose 5%	25	France	Marmande	664	0.41
Patient preparation					
Oxybuprocain single dose	1	France	Clermont-Ferrand	418	0.50
Betadine OPH 5%	25	France	Marmande	664	1.14
Disinfection tray	22	Bulgaria	—	2462	0.28
Xylocaïn gel	36	Sweden	Björkbornsvägen	1794	1.43
Operating table					
BSS 500	539	California, USA	—	9446	2.30
Adrenalin	1	France	Lyon	466	0.47
Disposable surgical Instruments: cataract pack	175	China, UK	—	8017	16.35
Disposable ophthalmological pack (patient's and table's drapes, cup, compresses)	660	France	Chateaubriand	352	26
Phacoemulsifier fluidic pack	316	Texas, USA	Houston	8081	64.4
Betadine single dose 5%	25	France	Marmande	664	1.14
Rycroft canula	1	Mexico	Tijuana	2959	0.69
Hydro-dissection canula	1	UK	Bitford	569	0.89
15 blade	9	Japan	Toshigi	9639	3.95
2.2 blade	13	Mexico	Tijuana	9155	3.20
Visco-elastic system	62	California, USA	—	9446	17.82
Mydrane®	8	France	Chambray-lès-Tours	240	7
Steri-Strip®		Minnesota, USA	Saint-Paul	6895	Included in our disposable ophthalmolog-ical pack
Plaster	50	Poland	Wroclaw	1288	0.1
1 cm^3 screw syringe	1	Spain	Fraga	1015	0.04
5 cm^3 screw syringe	1	France	Le Pont de Claix	575	0.08
Hypodermic needle	1	Spain	—	1000	0.01
Cefuroxim	19	France	Clermont-Ferrand	418	6.12
Surgeon preparation[b]					
Tie-back surgical gown	156	France	—	—	3.80
Sterile gloves	68	Thailand	—	9390	1.48
Scrubbing brush	20	France	Chateaubriand	352	0.38
Mild soap	500	France	Pavé du Moulin	231	0.60
Hydroalcoholic solution	500	France	Pavé du Moulin	231	1
Intra ocular lens[c]					
IOL-1	112	UK	Cork	1186	90
IOL-2	115	Belgium	—	650	99.91
End of surgery care					
Tobradex®		Spain	Barcelona	1026	< 0.01 ns
Total MD				75,612	238.74
Total PP				15,800	20.58
Total				91,412	—

[a] Weight included the packaging as well the products, including their liquid portions.
[b] Two persons scrubbed in for each case: a surgeon and a resident.
[c] One IOL was implanted for each case but we used 2 different brands according to our habits. The estimated travelled distance for IOLs has been averaged for the two manufacturing sites.

pharmaceuticals accounted for the largest share of the total GHG emissions.

We have analyzed our data and compared them with published studies according to the ''5R strategy'': reduce, reuse, recycle, rethink and research.

Reduce

Our data provide a basis to quantify cataract surgery as a provider of GHG and suggest that reductions in emissions can be achieved. Our study showed that the items used for cataract surgery in our center were manufactured on average 2856 km away from our hospital. The subject of local vs. globalized production of goods is often at the center of the ongoing political debate worldwide. Limiting the distance between the production of medical items and users may be one of the examples fueling these discussions.

In a department of orthopedics, a study focused on hand surgery has shown that a lighter instruments set could reduce waste by 13% [17]. Our custom packs, as used in our study, contain only 6 instruments. This streamlining does not leave any margin for further reduction regarding the share of these materials in our emissions. A recent report has shown that 43.5% of the pharmaceuticals prepared for cataract surgery were left unused [18]. Our own study was not set to distinguish unused products among our production of waste, but we reckon that reducing unused pharmaceuticals would lower our emissions. Our institution is located in the center of a large metropolitan area with an efficient network of public transport, which contributed to the reduction of GHG direct emissions linked to the transportation of staff. However, this did not apply to the patients, who usually reached our center by car on the day of their surgery. Ours is one of the largest and most renowned departments for cataract surgery in France, which may have attracted patients from further away than the average distance patients will usually cover between their homes and their closest eye care center. Different results could have been observed for a similar study performed in a rural area. Based on the preliminary results of our study we are currently working with hospital administrators and procurement offices to reduce our carbon footprint.

Reuse

In 2009, ASCRS published the ''Recommended practices for cleaning and sterilizing intraocular surgical instruments'' in order to prevent Toxic anterior segment syndrome (TASS) [19]. They recommend the use disposable cannulas and tubing whenever possible. Furthermore, since 1999, the World Health Organization (WHO) has recommended the use of disposable items with patients at risk of transmissible spongiform encephalopathies (TSE) especially in case of contact with brain, spinal cord and eyes [20]. There have been three reported cases of probable or possible transmission of classic Creutzfeldt—Jacob Disease via corneal grafts [21]. To our knowledge, no transmission has occurred due to surgical devices used for cataract procedures. Yet, the precautionary principle applies, and it is recommended hence to use disposable instruments rather than reusable ones. We suspect that disposable instruments generate more CO_2eq than reusable materials. However, further studies will be required to compare the carbon footprint of the sterilization of reusable products vs. using disposable instruments. We did not evaluate the GHG emissions related to the engineering, manufacturing, transportation and maintenance of the microscope and the phacoemulsifier, which can be used for several thousands of surgical procedures.

Recycle

The disposal of waste may also be improved. We have not analyzed our waste beyond dividing it into the categories of unregulated and regulated (biohazardous) medical waste. In ophthalmology, only needles and blades can be considered hazardous regulated medical waste. It has been estimated that disposing of 1 ton of regulated medical waste produces 934 kg CO_2eq, compared to 362 kg for domestic waste.[4] The recycling of waste may be another way to reduce the carbon footprint associated with medical activities [22]. Yet, as the processing of hazardous medical waste — including metal disposable instruments — is highly regulated, cost-effective recycling solutions remain to be developed [23].

Rethink

Although our study was based on assessing the GHG emissions during a single day of surgery, we believe that the principle of proportionality applies and that similar results would have been obtained by studying a larger set of procedures. Indeed, cataract procedures are highly standardized, with the same phacoemulsifier and disposables for each intervention; the average distance travelled by the staff is always the same; the calculations assessing the energy consumption of our building were based on applying the rule of proportionality to the annual consumption. The only factor that could differ from one day to another is the average distance travelled by the patients from their home to our center. We are confident that our data are reliable markers of an order of magnitude for GHG emissions for cataract surgery in France, but we acknowledge that variations are probable from one institution to another according to several parameters. We were unable to gather information regarding the transportation of raw material to the manufacturing sites. Our study was focused on the materials used in the operating suite and failed to take into account the disposable linen given to our patients. Our study did not precisely evaluate the plastic composition of the items used for the cataract procedures. Although biopolymers have been considered substitutes to conventional plastics, their environmental impact is still debated [24].

Research

Our data provide a basis to quantify cataract surgery as a provider of GHG and suggest that reductions in emissions can be achieved. However, further studies will be required to compare the carbon footprint of the sterilization of reusable products vs. using disposable instruments. Because of the current attention given to global warming and possible strategies to reduce GHG, one could speculate that this should be also taken into consideration in the methods used for cataract surgery [14]. Our calculated GHG per cataract procedure was equivalent to 810 km travelled by an average car.[4] Planting a single tree for every cataract procedure may balance its carbon footprint [25].

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jfo.2021.08.004.

Disclosure of interest

The authors declare that they have no competing interest.

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