ARTICLE

Potential environmental effect of reducing the variation of disposable materials used for cataract surgery

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Purpose: To analyze the cataract package variability in 1 country, Austria.

Setting: Austrian Departments of Ophthalmology.

Design: Cross-sectional study.

Methods: The cataract package components of 3 different Austrian hospitals were weighed and life cycle assessment on each product performed. This data was then extrapolated to the sales figures of the main Austrian cataract package suppliers to estimate the carbon footprint of all cataract packages used in Austria in 2021.

Results: There were 55 different cataract package compositions in use with an average weight of 0.7 kg. These compositions differ significantly in weight and composition considering that the smallest package was 57% lighter than the largest package. The size of the surgical drapes also showed considerable variation, with a difference of up to 71%. This is substantial, considering that drapes and covers account for about 53% of the package weight.

Conclusions: There was a considerable variation in package composition and product size, which could provide opportunities to save carbon dioxide emissions in cataract surgery. If all Austrian eye departments were to reduce the material quantities and drape sizes to the lower third of the cataract packages used in the Austria in 2021, cataract package associated CO_2 emissions could be reduced by 34%.

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The World Health Organization considers climate change to be the greatest threat to human health, with 13 million climate-associated deaths annually.[1] The global mean surface temperature for the decade 2006 to 2015 was 0.75 to 0.99°C higher than the mean over the 1850 to 1900 period, largely attributed to human activities. The years 2016 and 2020 were recorded as the hottest years since measurements began, with the International Panel of Climate Change (IPCC) calculating that the earth's temperature will continue to rise by a mean of 0.1 to 0.3°C per decade in the future if no action is taken.[2]

Globally, the healthcare sector is estimated to be responsible for 5% to 10% of all greenhouse gas emissions.[3–6] With approximately 30 million procedures annually, cataract surgery is one of the most commonly performed surgical procedures worldwide and could, therefore, be considered a significant carbon footprint contributor.[7,8] However, cataract surgery-associated carbon dioxide (CO_2) emissions vary worldwide. Cataract surgery using phacoemulsification in a British hospital resulted in 130 kg CO_2 eq. per surgery, which equals a 500-km drive with an average European car.[9,10] In comparison, cataract surgery in Southern India (Aravind Eye Care System) is emitting less CO_2 emissions with 6 kg CO_2 eq. per surgery. This equals a 25-km drive with the same vehicle. The Aravind Eye Care System saves CO_2 emissions primarily by reusing sterilized surgical materials, such as instruments, syringes, needles, phacoemulsification tips, and surgical gowns.[11] Despite the material-saving methods, the endophthalmitis rate over an 8-year period and approximately 2 000 000 procedures has been reported to not be significantly different (0.01%) than that of the United States (0.04%).[12]

The amount of material and waste in cataract surgery also seems to be considered excessive by surgical staff. From a survey of the Ophthalmic Instrument Cleaning and Sterilization Task Force with 1300 responses, which addressed the topic of "waste management" in cataract surgery, more than 90% of the participants stated that the

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surgical waste in cataract operations is found to be excessive. In addition, 95% believe that the use of disposable products unnecessarily increases surgical waste; 97% also believe that manufacturers encourage the use of disposable products; and 79% of participants would prefer reusable products over disposable products for the same cost.[13] The aforementioned UK-based study by Morris et al. also highlighted that the procurement of surgical supplies accounts for the largest share of the cataract-associated carbon footprint at 54%.[9]

To date, there is no study that analyzed the material composition and waste management of disposables in cataract packages used during cataract surgery. The aim of this study was to evaluate the variability in cataract package composition used throughout an exemplary country, namely Austria, and to provide recommendations for more sustainable cataract package compositions and the potentially achievable effect on CO_2 reduction. In addition, the current state of waste separation in Austrian cataract surgery and the possible CO_2 reduction will be assessed.

METHODS

Material Analysis

The different materials of the individual cataract package components of 3 Austrian hospitals (Hanusch Krankenhaus Wien, Barmherzige Brüder Wien and Privatklinik Hochrum) were separated (for example plastic from paper packaging), weighed, and categorized based on their properties. For this purpose, a search was conducted in the gray literature to look for manufacturer information on the product components. If it was not possible to obtain clear information on the materials, an assessment was made based on specific characteristics. In uncertain cases, the worst material from an eco-balance perspective was used for the life-cycle analysis calculation. Based on these data, the global warming potential (GWP) of each product is calculated using the GaBi Product Sustainability and Performance software. The environmental effects assessed using this software underlie the Environmental Footprint 3.0 (EF 3.0) methodology, developed by the European Commission. In this report, the focus is set on the carbon footprint and the respective EF 3.0 category “EF 3.0 Climate Change—total” considering the effects on climate change from fossil greenhouse gas emissions and removals, biogenic methane emissions, and carbon emissions from land use and land use change. The EF 3.0 Climate Change—total is based on the current IPCC characterization factors taken from the Fifth Assessment Report [10] for a 100-year time frame (GWP100), which is currently the most used metric for climate change analyses.[14] It should be emphasized that certain disposables (cassette and tubing) and external factors, such as hospital electricity consumption (scope 2 emissions), transport of staff and patients to and from the hospital, pharmaceuticals used before and in the operating room (OR), and other consumptions outside the cataract OR, are not included in the emission calculation for comparability reasons.

Procurement at Austrian Eye Departments

Cataract package sales lists are provided by the 3 main Austrian cataract package suppliers (estimated 94% market share in 2021). For the analysis, the products are divided into categories of surgical gowns, cannulas, syringes, postoperative eye protection, surgical trays/bowls, knives, fluid management (stick swabs, compresses, cotton balls), drapes/covers, and packaging for ease of reference. Using the data from the 3 hospitals mentioned in the preceding paragraph, a mean weight and carbon emissions of each product type is calculated, which is then multiplied by the sales figures of the cataract packages from the 3 suppliers. This results in a representative weight and CO_2 balance representing 94% of all cataract packages used throughout Austria. Particular attention is paid to the quantities and size variations between the varying cataract package compositions. Table 1 lists all cataract-relevant materials that are included in the calculations, and it also summarizes which data are excluded from the analysis.

Survey on Material Management in Austrian Cataract Surgery

A survey with 19 multiple-choice and 4 yes/no questions was sent out to all Austrian eye departments that perform cataract surgery with the help of the Austrian Ophthalmological Society and the Association of Austrian Eye Surgeons. In addition to these questions, free-text fields allowed participants to list comments on the topics for each item, and the responses were anonymized.

RESULTS

Material Analysis

On average, the cataract packages of the 3 hospitals contained 0.74 kg of materials, which corresponded to 2.3 kg CO_2 eq. per package. This did not include phaco cassettes, tubing, infusions with cutlery, and other cataract package external disposables. Drapes and covers accounted for most of the weight with 0.44 kg (52%). This was followed by surgical gowns with 0.22 kg (∼30%) and packaging with approximately 0.09 kg (12%) (Figure 1).

Furthermore, 16 different materials were found in the surgical products and their packaging. The majority was made up of fleece, a mixture of cellulose and polyethylene terephthalate (0.3 kg; 40%), which is found in drapes and surgical gowns. In addition, approximately 0.37 kg (50%) of the material quantity was composed of plastics. Among these, 8 different types of synthetics were identified. Table 2 lists these individual materials divided by product category.

Procurement at Austrian Eye Departments

In 2021, the 3 suppliers included in this study covered approximately 94% of all Austrian cataract package trade, which is 88 579 of a total of 93 799 procedures, based on data from the Kliniksuche.at website of the Austrian Ministry of Health.

There were 55 different cataract package compositions in use, with a mean cataract package weight of 0.7 kg. The estimated weight of cataract package materials provided by the 3 suppliers for 2021 was 61 944 kg. There was a variation between the package sizes, with the smallest package weighing a total of ∼0.5 kg and the largest one weighing ∼1.2 kg. The 2 categories “drapes and covers” and “surgical gowns” accounted for the largest portion of the weight as shown in Figure 2. For instance, 8 different types of drapes were found in the largest package and 2 in the smallest one. By contrast, other categories, such as the surgical gowns and the packaging material, were relatively similar in all packages.

In addition to the differences in quantity between the cataract package compositions, it was also noticeable that there were differences in product size, especially in the “drapes and covers” category. Figure 3 shows the variation

Table 1. Included and excluded cataract package materials used to calculate the weight and greenhouse gas

Included data		Excluded data
Products	**Packaging**	**Products and associated packaging (not separately listed)**
Knives		
Phaco knives	Packaging phaco knife	Surgical gloves and opthalmic viscoelastic device
Paracentesis knives	Packaging paracentesis knife	
Cannulas (18-30 gauge)	Cannula cover/packaging	Medication and infusion solution with cutlery
Fluid management		
Stick swabs	Bag for swabs, compresses, syringes, etc.	Phaco cassettes and tubing
Compresses		
Cotton balls		
Surgical gowns (M/L/XL)	Cataract kit bag with product list	Bag for swabs, compresses, syringes, etc.
Postoperative eye cover		Individually occurring single-use, surgical instruments: disposable clamps, forceps, manipulator, chopper, shears, hooks, etc.
Surgical trays/bowls		
Syringes		
Drapes and covers		
Body drape		
Back table cover/wrapping drape		
Armrest covers		
Multipurpose drape (if listed separately)		

of the individual cloth sizes in the subcategories body drapes, back table covers, wrapping cloths (if listed separately to back table covers), multipurpose covers, and armrest covers extrapolated to the sales figures of 2021. The difference of the smallest and largest body drapes sold was approximately 71% (1.22 vs 4.21 m^2).

Regarding the environmental effect, the GWP for all cataract packages sold in 2021 with an assumed waste incineration rate of 100% for all products was 209 380 kg CO_2 eq. (2.4 kg CO_2 eq. per cataract package). With an assumed recycling rate of 100% of all technically recyclable materials (i.e., packaging materials that are not contaminated in the OR), the carbon footprint was 195 804 kg CO_2 eq. (2.2 kg CO_2 eq. per cataract package). The difference in the CO_2 effect between cataract packages with 100% incineration and those with 100% recyclable materials was, therefore, approximately 6.5% (13 576 kg CO_2 eq.).

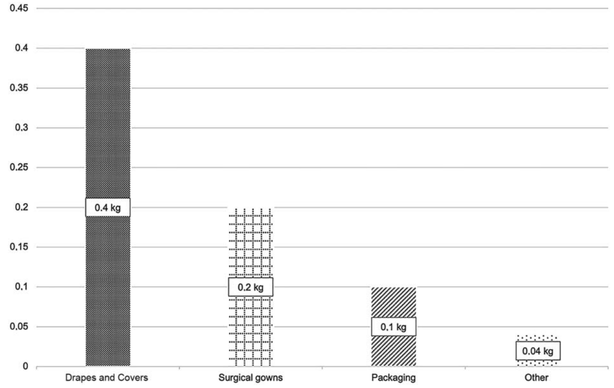

Figure 1. Percentages of individual categories of materials, based on the 3 analyzed cataract packages (mean weight per cataract package = 0.74 kg). *Other: postoperative eye covers, cannulas, knives, syringes, and fluid management.

Survey on Material Management

A total of 25 eye departments participated in the survey, which in total performed approximately 77% of cataract surgeries in Austria (2021). Besides the mandatory waste containers (puncture-proof disposable container and hospital waste) in use at all departments, approximately one-fifth of the participating hospitals did not use recycling-relevant waste containers (paper and plastic waste) for cataract surgery. Furthermore, approximately half of all departments (13 of 25) separated operating waste, with 10 of the 13 waste-separating departments additionally discarding the plastic and paper materials individually.

DISCUSSION

There is a surprisingly large variation in cataract package size and weight between surgical centers in Austria. There seems to be a cluster of relatively small, low-weight packages and a significant number of outliers with especially many large drapes and other materials either not found in the smaller packages or at least found in a smaller number. This variation is surprising since the technique of cataract surgery is essentially the same throughout Austria. Owing to the relatively small size of the country (8.95 million inhabitants, Statistik Austria; www.statistik.at) and the fact that more than 95% of cataract surgeries are performed in 33 public hospitals, the data and the questionnaire on waste management represent a large share of departments and, therefore, allow extrapolation to the entire cataract surgeries performed in Austria.[15]

Table 2. Mean weight of the materials used broken down by product category

Materials (divided by product category)	Mean weight (g)	Percentage (based on total weight)
Postoperative eye cover	15.24	1.72
Pulp	11.95	1.35
PVC	3.29	0.37
Cannulas	0.86	0.10
PP	0.66	0.07
Steel	0.20	0.02
Plastic packaging	54.60	6.17
HDPE	4.14	0.47
LDPE	39.66	4.48
PET	9.51	1.07
PS	1.29	0.15
Knives	6.36	0.72
HDPE	5.95	0.67
PVC	0.35	0.04
Steel	0.06	0.01
Surgical gowns	222.00	25.07
Cartonage	4.36	0.49
Nylon (polyamide)	1.20	0.14
Fleece (pulp/PET)	216.44	24.44
Paper packaging	34.12	3.85
Yarn	0.36	0.04
Paper	26.70	3.02
Paper-coated	7.06	0.80
Syringes	19.79	2.35
HDPE	4.52	0.51
PP	14.96	1.69
Styrene-Butadiene	1.31	0.15
Drapes and covers	383.33	59.31
Yarn	0.06	0.01
HDPE	2.17	0.34
LDPE	73.53	11.38
Paper	55.56	8.60
Paper-coated	61.68	9.54
PVC	1.49	0.23
Steel	1.49	0.23
Fleece (pulp/PET)	162.09	25.08
Pulp	25.28	3.91
Fluid management (compresses, stick swabs, cotton balls)	6.31	0.71
HDPE	1.13	0.13
Wood	0.85	0.10
Paper	1.18	0.13
Pulp	3.15	0.36
Total	741.60	100

HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; PP = polypropylene; PS = polystyrene; PVC = polyvinylchloride

Material procurement is an area where carbon quantities could be mitigated. According to Morris et al., it is responsible for 53.8% of cataract surgery-related CO_2 emissions, with medical products accounting for the largest share at 32.6%.[9]

In cataract surgery, there seems to be a tendency over the past few decades to prefer medical disposables over reusables.[16] This could be attributed to the risk of prion transmission, which around 1996 necessitated costly sterilization processes of surgical areas and reusable surgical items.[17] However, in its statement in 2016, the WHO argued against an increased risk of surgical site infections when using reusable compared with disposable materials.[18]

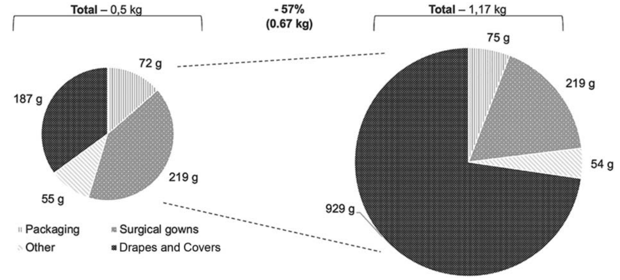

Figure 2. Weight difference between the smallest and largest cataract packages sold in 2021 broken down by product category (g). *Other: syringes, cannulas, knives, and postoperative eye covers.

The increased use of disposable materials might, therefore, have been kept unchanged out of habit. In the literature, the change from avoidable disposable materials to reusable materials and the resulting effect on the carbon footprint is debated. A review by Bolten et al. looking at infection prevention measures in the operating theater suggested that the use of reusable vs disposable textiles may be less environmentally harmful, although they are more energy-intensive to produce and must be disposed of after 75 to 100 uses to ensure an aseptic environment. It estimated that the use of reusable surgical gowns could reduce energy consumption by 64% and the carbon footprint by 66% compared with single-use gowns. Reuse of surgical instruments could also have a better environmental profile. For example, a study by Thiel et al. in the field of gynecology and obstetrics showed that reprocessing surgical instruments, surgical towels, surgical gowns, and drapes could reduce the carbon footprint from medical materials in a hysterectomy by 50% to 70%. A study by McGain et al. looking at the reuse of laparoscopes claimed that switching from disposable to reusable laparoscopes can increase CO_2 emissions by 9% in Australia, but reduce CO_2 emissions by 84% in the United Kingdom or continental Europe and 48% in the United States.[19,20] It could, therefore, be that the effect on carbon emissions by using reusable materials is dependent on the energy resource of the country in question. In the field of cataract surgery, there is a lack of data on the subject. At the time of publication, there were no studies addressing the switch from single-use to reusable materials in cataract surgery.

Based on the data from Austria, a first step toward more sustainable cataract surgery should lie in reducing the number of disposable products used per cataract package. A first step to decrease cataract surgery-associated carbon emissions could lie in reducing the number of materials used per cataract package. After all, cataract package volumes in Austria vary considerably (∼0.5 kg smallest cataract package and ∼1.2 kg largest cataract package). If all eye departments in Austria were to reduce their cataract

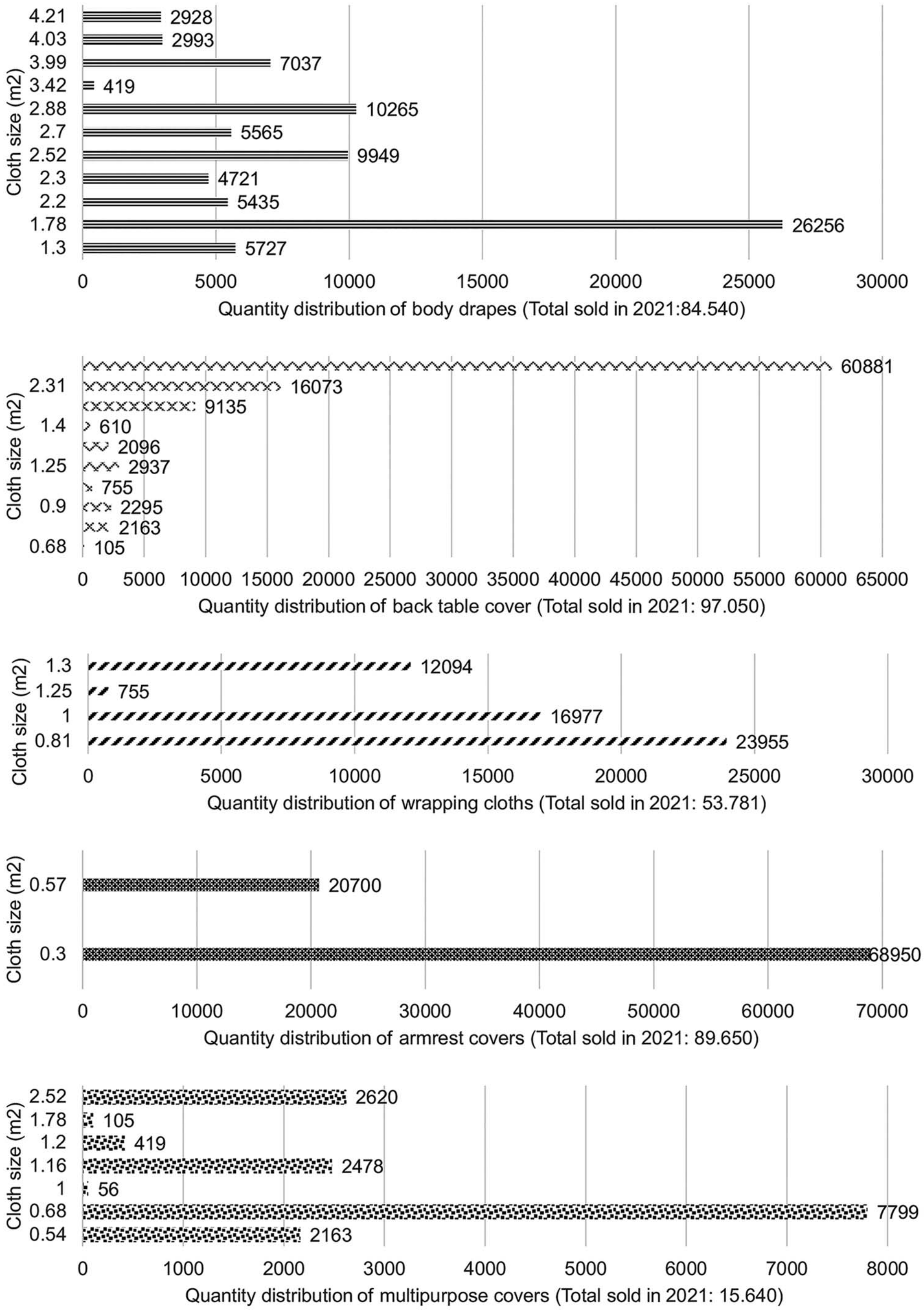

Figure 3. Sales of individual drapes and cloths extrapolated from the data of the 3 main Austrian suppliers. The figures are separated by their respective categories as mentioned in the sales figures for 2021 and broken down by cloth size (m^2) to show the significant variation throughout the country.

packages to a package size that is the mean weight of the lower third of the cataract packages used in 2021, the carbon footprint from cataract package waste would be reduced by approximately 20% (162 049 kg CO_2 eq. compared with 202 592 kg CO_2 eq.). It should be noted that the 3 included suppliers have not provided any information on more sustainable measures themselves; these data are merely based on the cataract set variation between the 55 cataract package compositions in the 2021 sales figures. The largest contribution to this CO_2 reduction would be achieved by reducing the number of drapes and covers, considering that they make up the largest part of the package weight at 53.1% (32 440 kg/61,944 kg) and show considerable variation between the packages (2 in the smallest and 9 in the largest package). It should be emphasized that for this calculation, packages where the number and weight of products are below the calculated "lower one-third" are left as they were, so were not adapted since this represents the amount needed. The materials found in this mean lower one-third package, which is derived from the data, are summarized in Table 3. This may serve as a first benchmark or blueprint concerning package size.

Keeping in mind that drapes and covers account for the largest portion of weight per package, reducing the size of

Table 3. Cataract package composition of the lower one-third of cataract packages used in Austria in 2021

Products	Quantity per package (based on amount sold in 2021)		Selected products per category	
	Weighted mean values per cataract package	Rounded lower third (2/3[a])	Product	Weight total (mean; packaging included)
Eye protection cover	1	1 (0.66)	Eye protection cover	3.4 g
Fluid management	17.4	11 (11.4)	Five compresses	10.9 g
			Five stick swabs	3.9 g
			Towel or instrument wipe	0.8 g
Cannulas	3.78	3 (2.53)	Three cannulas (cystotome included, gauge not specified)	5 g
Knives	2.8	2 (1.8)	Phaco knife	14.6 g
			Paracentesis knife	14.9 g
Surgical gown (exception, since op)	2.1	2 (1.4)[a]	Two surgical gowns (size not specified)	109.7 g (mean)
Operating bowl/tray	0.61	0 (0.4)	One[b]	
Syringes	4.2	3 (2.8)	10 mL syringe	7.7 g
			5 mL syringe	5.1 g
			3 mL syringe	3.3 g
Covers and drapes	3.6	2 (2.4)	Body drape with incision foil (as small as possible)	76.3 g/m^2
			Back table cover/wrapping cloth (as small as possible)	54 g/m^2

The weighted mean values of the total sales figures were calculated for each product category; from that, the lower third was determined. The weight data are based on the mean product weights from the material analysis.
[a]Exception since operating room nurses need gowns
[b]If possible, none—reusable cups

these offers another opportunity to cut carbon emissions. The difference in size of the smallest and largest drapes is 71% (1.22 to 4.21 m^2) (Figure 3). If all Austrian eye departments were to use the sizes of drapes and covers that are in the lower one-third used in 2021, the environmental effect could be lowered by 13% (175 286 kg CO_2 eq. compared with 202 592 kg CO_2 eq.). Considering that these have already been in use in Austria, this should not give rise to any concerns from a hygiene perspective.

From a legislative point of view, there is also no objection to reducing the size of the drape to the lower third already in use in Austria. The European Medical Devices Directive, which supersedes the Austrian Medical Devices Act (cf. § 5 para. 1 cl. 1 österreichisches Medizinproduktegesetz 2021), specifies material properties such as resistance to liquid penetration, resistance to microbial penetration, microbial cleanliness, particle release, and burst and tensile strength in wet and dry state, but does not give clear guidance on the size of drapes and gowns, leaving this to the subjective judgment of the practitioner. Factors such as comfort, manipulation through the placement of surgical instruments, and close contact with the patient/surgery staff should be considered (cf. E2.3 in EN 13795-1: 2019-06 “Surgical gowns and drapes—Requirements and test methods—Part 1: Surgical drapes and gowns”).

It is difficult to analyze the reasons for the large variation in cataract package content and weight. It seems as if the large packages used in numerous eye departments have historical reasons and were never changed since they have not caused problems. Reducing the material quantity may need some adaptation for surgeons and nurses; however, this should not result in increased risks for patients since many eye departments use these smaller packages without problems. A benefit for the departments could be lower costs when changing to smaller packages.

In Austria, sustainable management of surgical materials in the cataract operating room seems to have a certain priority in approximately 50% of the surveyed departments, which recycle noncontaminated packaging materials. According to the analysis, preoperative waste separation of packaging materials may potentially cut the cataract material-induced carbon emissions by approximately 3.25%, considering that the CO_2 emissions between 100% incineration of surgical materials (total CO_2 effect of 209 380 kg CO_2 eq. for 2021) and 100% recycling of recyclable materials (total CO_2 effect of 195 804 kg CO_2 eq. for 2021) differ by 6.5% and half of the Austrian eye departments already separate waste. It should be emphasized that, based on the results of the material analysis, all plastic components of the cataract-set packaging (high-density polyethylene, low-density polyethylene, polyethylene terephthalate, and polyethylene, which together account for 61.5% of the total packaging waste) are recyclable, if not contaminated (Table 2).[21]

Reasons for why only 50% of the Austrian eye departments separate surgical waste can only be assumed. On the other hand, it could be based on aspects of convenience, as extra waste containers would be needed and space in the operating area may be limited. In addition, it could also be because surgical staff are not adequately informed about the usefulness of waste separation, or, if materials are separated incorrectly, the recycling company may even penalize the eye departments.

There are some limitations of this study since only cataract package materials were evaluated for this study. Other disposables, such as opthalmic viscoelastic device, phaco cassettes and tubing, infusions with cutlery, medications, and other procedure relevant materials, were not included in the analysis. In addition, single-use items found scarcely in cataract packages (gloves, single-use cystotomes, forceps, eye speculums, etc.) were not taken into account for better comparability. It should again be emphasized that material weights and the CO_2 values for the disposables were extrapolated from the mean of the cataract packages provided by the 3 Austrian hospitals (Hanusch Krankenhaus, Barmherzige Brüder Wien, Privatklinik Hochrum), and the actual values may, therefore, vary slightly because of product diversity.

To summarize, if all eye departments in Austria were to reduce the number and size of materials in the cataract packages to the mean size of the lower third of the packages used at present and separate packaging materials accordingly, this could result in a reduction of CO_2 emissions by 34% (134 586 kg CO_2 eq.). Making these rather small adaptations, without a plausible risk concerning patient safety, and setting a "best practice cataract package" (the "Austrian standard cataract package") for sustainability may be a first and rather easy step toward reducing carbon emissions of cataract surgery in a meaningful way.

WHAT WAS KNOWN

- There is a significant global variation in carbon footprint when procuring and recycling disposable medical materials, considering the variation in CO_2 emissions between the United Kingdom and India.
- The medical material accounts for 32.6% of the carbon footprint resulting from cataract surgery.

WHAT THIS PAPER ADDS

- Further in-depth analysis is needed in disposable variation in a European country, namely Austria. There is a clear diversity in quantity and size of the different cataract package compositions used in the country, especially in the drapes and covers category, which make up the largest part of the package (~53%).
- If this variation of disposable materials in the cataract package was to be reduced, it could lead to a CO_2 reduction of up to 34%.
- This article gives first recommendations for a reduced cataract package composition based on the data collected in Austria.

REFERENCES

1. Prüss-Üstün A, Wolf J, Corvalán C, Bos R, Neira M. Preventing Disease Through Healthy Environments: A Global Assessment of the Burden of Disease From Environmental Risks. Geneva, Switzerland: World Health Organization; 2016
2. Summary for policymakers. In: IPCC, ed. Global Warming of 15°C: IPCC Special Report on Impacts of Global Warming of 15°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Cambridge, UK: Cambridge University Press; 2022:1–24
3. Eckelman MJ, Sherman JD. Estimated global disease burden from US health care sector greenhouse gas emissions. Am J Public Health 2018; 108:S120–S122
4. Eckelman MJ, Sherman JD, MacNeill AJ. Life cycle environmental emissions and health damages from the Canadian healthcare system: an economic-environmental-epidemiological analysis. PLoS Med 2018;15:e1002623
5. Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care. Lancet Planet Health 2018;2:e27–e35
6. Nansai K, Fry J, Malik A, Takayanagi W, Kondo N. Carbon footprint of Japanese health care services from 2011 to 2015. Resour Conserv Recycl 2020;152:104525
7. Khor HG, Cho I, Lee KRCK, Chieng LL. Waste production from phacoemulsification surgery. J Cataract Refract Surg 2020;46:215–221
8. Bourne RRA, Stevens GA, White RA, Smith JL, Flaxman SR, Price H, Jonas JB, Keeffe J, Leasher J, Naidoo K, Pesudovs K, Resnikoff S, Taylor HR; Vision Loss Expert Group. Causes of vision loss worldwide, 1990–2010: a systematic analysis. Lancet Glob Health 2013;1:e339–e349
9. Morris DS, Wright T, Somner JEA, Connor A. The carbon footprint of cataract surgery. Eye (Lond) 2013;27:495–501
10. Fontaras G, Samaras Z. On the way to 130 g CO_2/km—estimating the future characteristics of the average European passenger car. Energy Policy 2010;38:1826–1833
11. Thiel CL, Schehlein E, Ravilla T, Ravindran RD, Robin AL, Saeedi OJ, Schuman JS, Venkatesh R. Cataract surgery and environmental sustainability: waste and lifecycle assessment of phacoemulsification at a private healthcare facility. J Cataract Refract Surg 2017;43:1391–1398
12. Haripriya A, Chang DF, Ravindran RD. Endophthalmitis reduction with intracameral moxifloxacin in eyes with and without surgical complications: results from 2 million consecutive cataract surgeries. J Cataract Refract Surg 2019;45:1226–1233
13. Chang DF, Thiel CL. Survey of cataract surgeons' and nurses' attitudes toward operating room waste. J Cataract Refract Surg 2020;46:933–940
14. Stocker T. Climate change 2013: The physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2014
15. Austrian Federal Ministry of Social Affairs, Health, Care and Consumer Protection. Kliniksuche.at. Available at: https://kliniksuche.at/suche/abteilungen?abteilung=41&typ=1. Accessed October 8, 2022
16. Laufman H, Belkin NL, Meyer KK. A critical review of a century's progress in surgical apparel: how far have we come? J Am Coll Surg 2000;191: 554–568
17. Thomas JG, Chenoweth CE, Sullivan SE. Iatrogenic Creutzfeldt-Jakob disease via surgical instruments. J Clin Neurosci 2013;20:1207–1212
18. Allegranzi B, Zayed B, Bischoff P, Kubilay NZ, de Jonge S, de Vries F, Gomes SM, Gans S, Wallert ED, Wu X, Abbas M, Boermeester MA, Dellinger EP, Egger M, Gastmeier P, Guirao X, Ren J, Pittet D, Solomkin JS; WHO Guidelines Development Group. New WHO recommendations on intraoperative and postoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis 2016;16:e288–e303
19. Bolten A, Kringos D, Spijkerman I, Sperna Weiland N. The carbon footprint of the operating room related to infection prevention measures: a scoping review. J Hosp Infect 2022;128:64–73
20. Thiel CL, Woods NC, Bilec MM. Strategies to reduce greenhouse gas emissions from laparoscopic surgery. Am J Public Health 2018;108:S158–S164
21. Marsh K, Bugusu B. Food packaging—roles, materials, and environmental issues. J Food Sci 2007;72:R39–R55

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