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Supplemental Material

Operating in a Climate Crisis: A State-of-the-Science Review of Life Cycle Assessment within Surgical and Anesthetic Care

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Box S1: Scopus search strategy

Bibliographic Database: Scopus
Temporal scope: Inception to May 15, 2020

Query string: TITLE-ABS-KEY (("lifecycle assessment*" OR "life cycle assessment*" OR "lifecycle analys*" OR "global warming" OR "greenhouse gas*" OR "GHG" OR "environmental impact*" OR "carbon footprint") AND ("surger*" OR "surgical" OR "surgeon" OR "operating room*" OR "operating theat*" OR "perioperative" OR "medical procedure*" OR "medical equipment" OR "anesthe*" OR "anaesthe*"))

Box S2: PubMed search strategy

Bibliographic Database: PubMed
Temporal scope: Inception to May 15, 2020

Query string: (("Carbon Footprint"[Mesh] OR "Environmental Indicators"[Mesh] OR lifecycle assessment*[tiab] OR life cycle assessment*[tiab] OR life cycle analys*[tiab] OR global warming[tiab] OR greenhouse gas*[tiab] OR GHG[tiab] OR environmental impact*[tiab] OR carbon footprint*[tiab]) AND ("surgery"[Subheading] OR "Surgical Procedures, Operative"[Mesh] OR "Hospital Units"[Mesh] OR surger*[tiab] OR surgical*[tiab] OR surgeon*[tiab] OR operating room*[tiab] OR operating theat*[tiab] OR perioperative[tiab] OR medical procedure*[tiab]))

Box S3: Embase search strategy

Bibliographic Database: Embase
Temporal scope: Inception to May 15, 2020

Query string: (('carbon footprint'/exp OR 'lifecycle assessment*':ti,ab,kw OR 'life cycle assessment*':ti,ab,kw OR 'life cycle analys**':ti,ab,kw OR 'global warming':ti,ab,kw OR 'greenhouse gas*':ti,ab,kw OR 'ghg':ti,ab,kw OR 'environmental impact*':ti,ab,kw OR 'carbon footprint':ti,ab,kw) AND ('surgery'/exp OR 'operating room'/exp OR ('hospital subdivisions' AND components) OR surger*:ti,ab,kw OR surgical*:ti,ab,kw OR surgeon*:ti,ab,kw OR 'operating room*':ti,ab,kw OR 'operating theat*':ti,ab,kw OR perioperative*:ti,ab,kw OR 'medical procedure*':ti,ab,kw OR 'medical equipment':ti,ab,kw OR anesthe*:ti,ab,kw OR anaesthe*:ti,ab,kw))

Box S4: Benchmark articles

Brown et al. (2012):

- Gatenby PAC. Modelling the carbon footprint of reflux control. Int J Surg. 2011;9(1):72---74.
- Somner J, Scott K, Morris D, Gaskell A, Shepherd I. Ophthalmology carbon footprint: something to be considered? J Cataract Refract Surg. 2009;35(1):202---203.
- Gilliam AD, Davidson B, Guest J. The carbon footprint of laparoscopic surgery: should we offset? Surg Endosc. 2008;22(2):573.
- Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: application to clinical use. Anesth Analg. 2010;111(1):92---98

McGain and Naylor (2014):

- Campion N, Thiel CL, DeBlois J, Woods NC, Landis AE, Bilec MM. Life cycle assessment perspectives on delivering an infant in the US. Sci Total Envir 2012; 425: 191–198.
- Morris D, Wright T, Somner J, Connor A. The carbon footprint of cataract surgery. Eye 2013; 27(4): 495-501.
- Overcash M. A comparison of reusable and disposable medical textiles: state-of-the-art. Anes Analg 2012; 114: 1055-1066.
- Sherman J, Le C, Lamers V, Eckelman M. Life cycle greenhouse gas emissions of anesthetic drugs. Anesth Analg 2012; 114:1086-1090.

Alshqaqeeq et al. (2020):

- Andrews, E., Pearson, D., Kelly, C., Stroud, L., Perez, M.R., 2013. Carbon footprint of patient journeys through primary care: a mixed methods approach. Br. J. Gen. Pract. 63 (614), e595–e603.
- Somner, J.E.A., Stone, N., Koukkoulli, A., Scott, K.M., Field, A.R., Zygmunt, J., 2008. Surgical scrubbing: can we clean up our carbon footprints by washing our hands? J. Hosp. Infect. 70 (3), 212–215.
- Somner, J., Scott, K., Morris, D., Gaskell, A., Shepherd, I., 2009. Ophthalmology carbon footprint: something to be considered? J. Cataract Refract. Surg. 35 (1), 202–203.
- Power, N.E., Silberstein, J.L., Ghoneim, T.P., Guillonneau, B., Touijer, K.A., 2012. Environmental impact of minimally invasive surgery in the United States: an estimate of the carbon dioxide footprint. J. Endourol. 26 (12), 1639–1644.
- Gilliam AD, Davidson B, Guest J. The carbon footprint of laparoscopic surgery: should we offset? Surg Endosc. 2008;22(2):573.
- Morris, D.S., Wright, T., Somner, J.E.A., Connor, A., 2013. The carbon footprint of cataract surgery. Eye 27 (4), 495–501.
- Woods, D.L., McAndrew, T., Nevadunsky, N., Hou, J.Y., Goldberg, G., Yi-Shin Kuo, D., Isani, S., 2015. Carbon footprint of robotically-assisted laparoscopy, laparoscopy and laparotomy: a comparison. Int. J. Med. Robot. Comput. Assist. Surg. 11 (4), 406–412.
- Thiel, C.L., Eckelman, M., Guido, R., Huddleston, M., Landis, A.E., Sherman, J., Bilec, M.M., 2015. Environmental impacts of surgical procedures: life cycle assessment of hysterectomy in the United States. Environ. Sci. Technol. 49 (3), 1779–1786.
- Campion N, Thiel CL, DeBlois J, Woods NC, Landis AE, Bilec MM. Life cycle assessment perspectives on delivering an infant in the US. Sci Total Envir 2012; 425: 191–198.
- Gatenby PAC. Modelling the carbon footprint of reflux control. Int J Surg. 2011;9(1):72---74.
- Sherman J, Le C, Lamers V, Eckelman M. Life cycle greenhouse gas emissions of anesthetic drugs. Anesth Analg 2012; 114:1086-1090
- Weinberg, L., Tay, S., Aykanat, V., Segal, R., Tan, C., Peyton, P., Story, D., 2014. Changing patterns in volatile anesthetic agent consumption over seven years in Victorian public hospitals. Anaesth. Intensive Care 42 (5), 579–583.
- Tay, S., Weinberg, L., Peyton, P., Story, D., Briedis, J., 2013. Financial and environmental costs of manual versus automated control of end-tidal gas concentrations. Anaesth. Intensive Care 41 (1), 95.
- Eckelman, M., Mosher, M., Gonzalez, A., Sherman, J., 2012. Comparative life cycle assessment of disposable and reusable laryngeal mask airways. Anesth. Analg. 114 (5), 1067–1072.
- Ek, M., Tjus, K., 2008. Decreased emission of nitrous oxide from delivery wards—case study in Sweden. Mitig. Adapt. Strateg. Glob. Change 13 (8), 809–818.
- Campion, N., Thiel, C.L., Woods, N.C., Swanzy, L., Landis, A.E., Bilec, M.M., 2015. Sustainable healthcare and environmental life-cycle impacts of disposable supplies: a focus on disposable custom packs. J. Clean. Prod. 94, 46–55.

Table S1: Completed STARR-LCA Systematic Review Checklist

Item	Description	Included? (Y/N/I)	Comments
1. Document title, structured summary, and key words	- Title identifies article as systematic review, meta-analysis or both - Abstract contains background; objectives; data sources; study eligibility criteria; scope, system boundaries and functional unit; study appraisal and synthesis methods; results; limitations; and conclusions with implications for key findings - Key words include meta-analysis and/or systematic review	I	All of the components listed within the description were not able to be included within the abstract due to strict word limits. Excluded components (i.e. eligibility criteria, system boundaries, functional units) are addressed thoroughly within the main text and accompanying supplementary material.
2. Rationale of the review	- Purpose of review study in the context of current knowledge	Y	Detailed in the last paragraph of the Introduction. Further information is included within the registered protocol (Drew, 2020)
3. Review questions and objectives	- Question elements consistent with - PIFT format2	Y	Structured research question using PIFT framework included within registered protocol (Table 1; Drew, 2020)
4. Description of review protocol	- How possible studies or data for review were located - Information sources - Description of electronic search strategies - Process for selecting studies or data to include in the review summary - Description of further analyses	Y	Electronic search strategies documented in Boxes S1-3. The article screening and review process is documented within the main text and inclusion and exclusion criteria are summarized in Table S2. No 'further analyses' conducted.
5. Findings and features of individual studies in the review	- Include major findings, methods and limitations - Present data graphically if possible	Y	Tables 1-2 summarize methods of individual studies, while Figures 2-5 summarize major findings. Limitations are discussed within the Discussion.
6. Assessment of bias	- Assessment of bias for individual studies included and across studies when summarized - Statement of funding source for the review	Y	Eligible studies were critically appraised according to a pre-determined scoring system.
7. Synthesis methods	- Description of how data was summarized qualitatively and quantitatively	Y	Data synthesis and presentation is detailed within the last section of the Methods.
8. Limitations of the Review	- Limitations of methodology - Guidance about appropriate generalization or application of review findings	Y	-
9. Summary of findings and conclusions	- Clear conclusions - Discussion of conclusions in the context of other evidence	Y	-

Note: The STARR-LCA (Standardized Technique for Assessing and Reporting Reviews of Life Cycle Assessment Data) systematic review checklist was developed by Zumsteg et al., (2012); Y, yes; N, no; I, incomplete.

Table S2: Inclusion and exclusion criteria

Inclusion/Exclusion	Criterion	Category
Entries were excluded based on abstract screening if they:	Could not be accessed, were not written in English, or did not report on original research assessing environmental impact(s) in relation to healthcare	1
Potentially eligible entries were excluded based on full-text review if they:	Could not be accessed, were not written in English, or did not report on original research assessing environmental impact(s) in relation to healthcare	2
	Assessed healthcare-related environmental impact(s) but not in relation surgery or anesthesiology	3
	Assessed environmental impact(s) in relation to surgery or anesthesiology but did not use life cycle assessment	4
Studies were included if they:	Assessed the environmental impact(s) of an operating room(s) using life cycle assessment	5
	Assessed the environmental impact(s) of a specific surgical procedure(s) using life cycle assessment	6
	Assessed the environmental impact(s) of equipment or pharmaceuticals used in surgical settings	7

Note: 'Original research' refers to novel research as opposed to a review or synthesis of existing research; 'Environmental impact' refers to data on an environmental indicator(s), including but not limited to climate change (global warming potential), energy use, eutrophication, acidification, ozone layer depletion, toxicity, particulate matter formation, ionizing radiation, biodiversity loss, resource use (e.g. land, water), and waste; 'Surgery' refers to any aspect of the surgical discipline, including operating rooms, specific procedures or equipment and materials used in surgical settings; 'Life cycle assessment' refers to a standardized approach to assessing environmental impacts associated with the life cycle of a product, process, or service whereby an inventory of energy and material inputs and outputs of the relevant system is compiled, environmental impacts associated with the inventory are assessed, and results of the impact assessment are interpreted in the context of the initial scope and objectives of the study (examples of standardized life cycle assessment approaches include but are not limited to: International Organization for Standardization (ISO) standards, Publicly Available Specification (PAS) 2050 Standard, Greenhouse gas (GHG) Protocol Product Standard or GHG Protocol Corporate Standard).

References

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Zumsteg, J. M., Cooper, J. S., & Noon, M. S. (2012). Systematic review checklist: A standardized technique for assessing and reporting reviews of life cycle assessment data. *Journal of Industrial Ecology*, *16*, S12–S21.