Appendix 1. Evidence tables
Evidence table for systematic reviews

Study reference	Study characteristics	Product/service characteristics	Intervention (I) and Comparison / control (C)	Follow-up	Outcome measures and effect size	Comments
Drew (2021)	SR of LCAs in anaesthetic and surgical care. It aims to summarize the state of LCA practice via review of literature assessing the environmental impact of related services, procedures, equipment and pharmaceuticals. Literature search up to may 2020 The review was guided by using STARR-LCA, which is a PRISMA-based framework. <u>Study design</u>: LCA <u>Setting and Country</u>: Anaesthetic and surgical care, Canada. <u>Source of funding and conflicts of interest:</u> None stated.	Inclusion criteria SR: Studies which assessed the environmental impact(s) of (1) an operating room(s) using LCA, (2) a specific surgical procedure(s) using LCA or (3) equipment or pharmaceuticals used in surgical settings. Exclusion criteria SR: No access, no English language, no research in relation to healthcare, healthcare related but not related to surgery or anaesthesiology, no use of LCAs. 44 included studies	These studies examined the impact contributions from **(A)** ORs generally (n=1) **(B)** specific surgical procedures (n=10) **(C)** provision and use of surgical or anaesthetic equipment or pharmaceuticals (n=33)	<u>End-point of follow-up</u>: N/A <u>For how many participants were no complete outcome data available?</u> N/A	**(A)** Operating rooms The climate impact of the hospitals' surgical suites ranged from 3,200,000 to 5,200,000 kg CO_2e per year and between 146 and 232 kg CO2e per operation (when compared on a caseload basis). **(B)** Surgical procedures The outcomes on climate change were found to vary considerably (6-1,007 kg CO_2e). See figure 2 (Drew, 2021). **(C)** Equipment and materials and pharmaceuticals Most disposable equipments/materials were more harmful for the environment compared to reusables. Figure 4 (Drew, 2021) includes the other outcome measures for provision and use of disposables relative to functionally equivalent reusables. For use of pharmaceuticals, GHG emissions from propofol were considerably lower than inhalational agents (i.e., desflurane, isoflurane and sevoflurane).	<u>Authors conclusion:</u> LCA data indicates the environmental burden attributable to the services is substantial and effective mitigation strategies are already available. Eligible studies varied in terms of quality, completeness and risk of bias, with critical appraisal scores varying between 44% and 89%. **(A)** Only one study is found comparing different ORs on environmental impact and identifying hotpots. Results could not be pooled. **(B)** The studies varied considerably in their system boundaries and functional units, which leads to heterogeneity of the studies. Results could not be pooled. **(C)** Functional units varied considerably between the studies. There is a high degree of heterogeneity, in terms of studied items and methodology. <u>Interpretation of results</u> **(A)** For the OR certain emission hotspots were identified: use of anaesthetic gases and use of HVAC. **(B)** OR energy was a great hotspot, mainly due to HVAC. Next to that provision and use of anaesthetic gases and production of equipment and

Study reference	Study characteristics	Product/service characteristics	Intervention (I) and Comparison / control (C)	Follow-up	Outcome measures and effect size	Comments
						consumables contribute mainly. **(C)** Considering the life cycle of single-use items, the most contributing phase is the production phase. Single-use items are more often worse for the environment compared to reusables. When using reusables the energy source has to be taken into account, since the reuse phase is the biggest contributor, which requires energy.

Evidence table for LCA studies

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
Grimmond (2012)	Waste Management & Research Journal information The journal for a sustainable circular economy. Fully peer-reviewed international journal that publishes original review articles relating to both the theory and practice of waste management and research. Mass flow analyses, life cycle assessments, policy planning and system administration, innovative processes and technologies and their engineering features and cost effectiveness are among the key issues that WM&R seeks to cover through well documented reports on new concepts, systems, practical experience (including case studies), and theoretical and experimental research work. Critical review: Peer reviewed journal. Not a specific LCA journal, however inclusion of LCA studies in scope of the journal.	Type of study: LCA Objective: To assess the climate impacts of two different sharps container systems (disposable and reusable) over a 12 month period. LCA-method: Attributional LCA Setting and country: Hospital US Facility: Northwestern Memorial Hospital (NMH, Chicago) Years of data collection: - Surgical discipline(s): Nonspecific Funding and conflict of interest: None	Goal and scope[1]: Comparison of contribution of disposable (DSC) or reusable sharps containers (RSC) to the global warming potential (GWP). Functional unit(s)[2]: Provision for 100 occupied hospital beds over one year System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Infrastructure and assets were excluded from both systems ("in accordance with product LCA principles") Inventory database: GaBi Allocation: No Normalization & Weighting: Results normalized to 100 occupied beds/year Impacts reported: Yes Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes; tests impact of distribution distances by assuming RSCs were made at the DSC facility, and vice versa; tests impact of equal sized container volumes; tests impact of	An LCA framework was used to assess the climate impacts of two different sharps container systems (disposable and reusable) over a 12-month period. Data was collected regarding the size, type, and number of containers used, as well as modification protocols. Both systems were taken into account from cradle to grave. The data comes from a variety of industry and government sources and combined with an LCI/LCA tool developed by the Waterman Group UK. Characterization methods: IPCC	1. Climate Change Annual greenhouse gas (GHG) emissions resulted in a Global Warming Potential (GWP) of 139.1 metric tons of (MT) CO_2 equivalents for DSC and 25.1 MTCO_2 equivalents for reusable sharps containers (RSC). Stratified to 100 hospital beds over one year this resulted in 24.2 MTCO_2 equivalents GWP per 100 OB-year for DSC and 4.0 MTCO_2 equivalents GWP per 100 OB-year for RSC. Use of RSC reduces GWP by 83.5%. 2. Waste Annual waste for DSC resulted in 30,920 kg landfilled plastic and 5020 kg of cardboard boxes for 34,396 manufactured and 33, 759 landfilled DSC (chemotherapy DSC were incinerated). Whereas RSC only caused 123 kg of plastic waste (calculated for the end of life of the RSC, during the study no RSC were landfilled) and 116 kg of waste from carboard boxes (this were the chemotherapy DSC, which were used in both systems if there was an indication for chemotherapy). In total 2481 RSC were manufactured and 47 containers were landfilled. 3. Acidification No results in this study. 4. Eutrophication No results in this study.	Use of RSC leads to reduction of GWP and waste. The manufacturing process is the biggest contributor in GWP for DSC, and thereby gives the largest difference between the two containment systems. This is a function of resin weight; container manufacturing and low annual RSC manufacturing emissions because of their long lasting life span. The washing process is the biggest contributor for RSC. Decanting and washing contributed for 52.5% of the systems total GWP. The sensitivity analysis showed that the choice of a 'clean' electrical source (e.g. windfarm vs. coal) can alter manufacturing GWP by 15% in the US. Thereby, it showed that water usage in RSC processing was associated with 40% of this process and reduction of water volumes would reduce GWP. Reclamation of energy and material will reduce manufacturing GWP in both systems.	Authors conclusion RSC significantly reduced GWP over DSC, with manufacturing and transport as the major contributors to the GWP of DSC. Larger containers have little GWP impact, transport distances and electricity sources are important factors. Limitations study The study is conducted in the USA with all processes related to 1 hospital, outcomes might changes for other hospitals and countries.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
			alternative electricity grids; tests transport vehicle load capacity; tests alternate disposal methods, e.g. shredding. Uncertainty analysis: No Variance analysis: Yes		5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	Costs were reduced by 19.2% by using RSC.	
Grimmond (2021)	BMJ open Journal information BMJ Open is an online, open access journal, dedicated to publishing medical research from all disciplines and therapeutic areas. Critical review: Peer reviewed. Not in specific LCA journal or LCA in scope of the journal.	Type of study: LCA Objective: To compare global warming potential (GWP) of hospitals converting from single- use sharps containers to reusable sharps containers (SSC, RSC). LCA-method: Attributional LCA Setting and country: Acute care hospital trusts in the UK Facility: 40 UK NHS hospital trusts using RSC Years of data collection: 2018-2019 Surgical discipline(s): Nonspecific Funding and conflict of interest:	Goal and scope[1]: To compare the life-cycle carbon footprint of 12-months usage of SSC with 12 months usage of RSC. Functional unit(s)[2]: Total fill line litres (FLL) of sharps containers needed to dispose of sharps for 1-year period in 40 trusts. System boundaries: Cradle to grave Included stages: Manufacture, transport, decanting and decontamination and treatment and disposal Stated excluded components: Capital machinery, infrastructure, vehicle life-cycle, labor, SC contents, non-GHG emissions Inventory database: Gabi database Allocation: Yes, annual emissions for RSC manufacturing were determined by dividing total manufacturing GHG by the years of life expectancy.	The global warming potential (GWP) of hospitals converting from single-use sharps containers (SSC) to reusable sharps containers (RSC) were compared by using an attributional LCA model. The intervention in this study was conversion from SSC to RSC. Twelve months of usage of SSC was compared with twelve months usage of RSC. SSC and RSC usage details in 17 baseline trusts immediately prior to 2018 were applied to the RSC usage details of the 40 trusts using RSC in 2019. The outcome measure was GWP. This was calculated in carbon dioxide equivalents (CO2 equivalents) generated in the manufacture, transport, service and disposal of 12 months, hospital-wide usage of both sharps containment systems in the 40 trusts. Characterization methods: IPCC	1. Climate Change Annual greenhouse gas (GHG) emissions in 40 trusts resulted in a Global Warming Potential (GWP) of 3896.4 metric tons of (MT) CO_2 equivalents for SSC and 628.9 $MTCO_2$ equivalents for RSC (-83.9%). 2. Waste Annual waste for SSC resulted in 928.7 kg incinerated plastic and 136.6 kg of cardboard boxes for 1 748 851 manufactured and 1 748 851 incinerated SSC. Whereas RSC were not incinerated – all parts were either reused or recycled. Waste in the RSC study-year came from SSCs used in study-year. 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	Use of RSC leads to reduction of GWP and waste. The manufacturing process is the biggest contributor in GWP for SSC, and thereby gives the largest difference between the two containment systems. Transport is the biggest contributor for RSC. It resulted in 442 MT CO_2 equivalents of the total of 628.9 MT CO_2 equivalents annually for 40 hospital trusts. The sensitivity analysis showed that that changes achieved by changing processes/geography within life stages, were not mirrored in the final GWP comparisons, which in all but one alternative scenario did not achieve changes for more than 5%. This was the RSC lifespan of 1 year, which was an academic exercise and is not expected in real life. Using larger vehicles for	Authors conclusion RSC achieved significant GHG reductions over SSC, container manufacture was the largest contributor in SSC, for RSC it was transport. RSC lifespans can be reduced and achieve marked GWP reductions over SSC. Adoption of reusable over SSC can reduce GHG emissions permanently with minimal staff behavioural change. Limitations study Results of SSC has been extrapolated from 17 trusts to 40 trusts and therefore the representativeness of data might not be accurate.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
			Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes; tests impact of larger vehicle size, transport distances, polymer and container manufacturing geographies, larger SSC container size and changing the lifespan from a base of 18 years to 1 year, theoretically maximum of 66 years and the 'break-point' at which life span RSC GWP matches SSC GWP. Uncertainty analysis: No Variance analysis: No			transport and optimization for reprocessing medical devices is recommended to lower GHG.	
Hicks (2016)	Environmental Science: Nano from 'The Royal Society of Chemistry' Journal information Information on the design and demonstration of engineered nanomaterials for environment-based applications and on the interactions of engineered, natural, and incidental nanomaterials with biological and environmental systems. • Novel nanomaterial-based applications for water, air, soil, food, and energy sustainability	Type of study: LCA Objective: To compare environmental impact of reusable patient hospital gowns coated with nAg (nanosilver) product to the use of disposable gowns. LCA-method: Attributional LCA Setting and country: USA Facility: Hospital case study Years of data collection: Not defined.	Goal and scope[1]: Analysis of the lifecycle impact of the synthesis of nAg, its application to textiles in a hospital setting and laundering of the textile. Functional unit(s)[2]: - 4600 ug of nAg (amount added to hospital gown) - Per one wear and laundering (over a lifetime of 75 wearings) System boundaries: Cradle to grave Included stages: Raw materials acquisition, manufacturing, use, end of life	An LCA was conducted to compare the environmental impact of reusable patient hospital gowns coated with nAg product compared to the use of disposable gowns. First, the environmental impact of synthesis and attachment of 4600 ug nAg was determined (the amount added to a hospital gown). Second the life cycle impacts of nanoscale silver (nAg)-enabled reusable hospital gowns per one wear are modelled and midpoint environmental data are compared. Characterization methods:	1. Climate Change Results using nanosilver (nAg) as an antimicrobial agent for patient hospital gowns. Given the observed loss of nAg, the silver could be reapplied at each set of 17 launderings for reusable gowns and needed to be reapplied for every single disposable gown. Greenhouse gas (GHG) emissions for synthesis of 4600 ug nanosilver resulted in a Global Warming Potential (GWP) of 1.17×10^{-3} kg CO_2 equivalents. Nanosilver attachment resulted in 7.90×10^{-2} kg CO_2 equivalents per hospital gown. 2. Waste No results in this study.	Nanosilver (nAg) can be used for patient hospital gowns due to its antimicrobial nature. The results show it is necessary to synthesize the nAg and thereafter attach the silver to the gown. The impact is greater to attach the nAg to the textile than it is to synthesize it. For reusable gowns the silver could be reapplied at each set of 17 launderings. This means the attachment has to be applied more often in disposable gowns, which would lead to a higher environmental impact. Next to that, the	Authors conclusion The energy consumption was found to be much less during the lifetime of the reusable hospital gown than continuously using disposables. This suggests that nAg-enabling of reusable hospital gowns may be a method for simultaneously lowering the environmental impact and maintaining the antimicrobial performance needed to combat pathogen transmission. Limitations study Only one attachment and synthesis process was analysed. The environmental impact of

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	• Nanomaterial interactions with biological systems and nanotoxicology • Environmental fate, reactivity, and transformations of nanoscale materials • Nanoscale processes in the environment • Sustainable nanotechnology including rational nanomaterial design, life cycle assessment, risk/benefit analysis Critical review: Peer reviewed journal. Not a specific LCA journal, however inclusion of LCA studies in scope of the journal.	Surgical discipline(s): Nonspecific Funding and conflict of interest: U.S. Environmental Protection Agency Assistance Agreement No. RD 83558001-0 funded this research.	Stated excluded components: - Inventory database: Ecoinvent database (v 2.2) Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes Scenario analysis: Yes Comparative analysis: Yes Sensitivity analysis: Yes Uncertainty analysis: Yes Variance analysis: No	TRACI	3. Acidification Acidification for synthesis of 4600 ug nanosilver resulted in 9.99 x 10^{-4} mol H^+ equivalents. Nanosilver attachment resulted in 2.66 x 10^{-2} mol H^+ equivalents per hospital gown. 4. Eutrophication Eutrophication for synthesis of 4600 ug nanosilver resulted in 5.83 x 10^{-5} kg N equivalents. Nanosilver attachment resulted in 2.63 x 10^{-4} kg equivalents per hospital gown. 5. Human Toxicity Human toxicity in carcinogenics for synthesis of 4600 ug nanosilver resulted in 4.66 x 10^{-10} CTUh. Nanosilver attachment resulted in 4.28 x 10^{-9} CTUh per hospital gown. Human toxicity in non-carcinogenics for synthesis of 4600 ug nanosilver resulted in 6.37 x 10^{-9} CTUh. Nanosilver attachment resulted in 4.28 x 10^{-8} CTUh per hospital gown. 6. Ecotoxicity Ecotoxicity for synthesis of 4600 ug nanosilver resulted in 2.36 x 10^{-2} CTUe. Nanosilver attachment resulted in 1.51 x 10^{-1} CTUe per hospital gown. 7. Ozone Depletion Ozone depletion for synthesis of 4600 ug nanosilver resulted in 1.29 x 10^{-10} kg CFC-11 equivalents. Nanosilver attachment resulted in 5.70 x 10-	sensitivity analysis shows reapplying the nAg every wash cycle for the reusable gown leads to a higher environmental impact compared to the disposable gown. After 28 cycles the impact of the reusable gown is lower compared to the disposable gown. When reapplying after every 17th cycle, the reusable gown has a lower impact compared to the disposable already at first use. This study shows that disposable patient hospital gowns coated with nAg lead to a higher environmental impact for compared nAg coated reusable gowns.	excess silver during synthesis and the silver lost is not explored. The comparisons of reusable and disposable gowns relies on prior work and utilizes only one impact category.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					[9] kg CFC-11 equivalents per hospital gown.		
McGain (2010)	Anaesthesia and Intensive Care Journal information Anaesthesia and Intensive Care is an international journal publishing timely, peer reviewed articles that have educational value and scientific merit for clinicians and researchers associated with anaesthesia, intensive care medicine, and pain medicine. It is the official journal of the Australian Society of Anaesthetists, the Australian and New Zealand Intensive Care Society and the New Zealand Society of Anaesthetists. Critical review: Peer reviewed. Not in specific LCA journal or LCA in scope of the journal.	Type of study: LCA Objective: To assess the environmental and financial impacts of two types of commonly used plastic anesthetic drug trays: a single-use polyurethane tray made in China and reusable (300 uses) nylon tray made in Australia. Impacts and financial costs of two cotton gauzes and one paper towel, which are included with most single-use trays, were separately modelled. LCA-method: Attributional LCA Setting and country: Australia Facility: Western Health, Melbourne, Victoria, Australia Years of data collection: - Surgical discipline(s): Anaesthesiology Funding and conflict of interest: None	Goal and scope[1]: To compare the financial and environmental costs of two commonly used anaesthetic drug trays. Functional unit(s)[2]: Use of one plastic anesthetic drug tray (+/- use of 2 cotton gauzes and 1 paper towel) System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Existing infrastructure for energy extraction and transportation was not included, nor was agricultural machinery, farm establishment, and forest establishment ("acquisition and infrastructure costs of machines or items that are already in place are routinely not included in LCAs") Inventory database: EcoInvent Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes, although alignment between reported	The financial and environmental costs of two commonly used anaesthetic drug trays were modelled using LCA. This study was performed at the Western Hospital in Melbourne, Victoria. The reusable tray, the single-use tray and the single-use tray with cotton and paper were compared. Data was collected directly from measurements and from databases (EcoInvent). The single-use trays were plastic Chinese-made trays and the reusable trays were Australian made nylon trays. Since not all data was directly available, an some data were also not available as average data, for the single-use trays the European energy mix is used, however the Chinese energy mix might be more coal reliant. Characterization methods: -	1. Climate Change The reusable tray produced 110 g of CO_2 (95% CI 98 to 122 g CO_2), the single use tray alone produced 126 g CO_2 (95% CI 104 to 151 g) with a mean difference of 16 g CO_2 (95% CI -8 to 40 g CO_2). The single use tray with cotton and paper produced 203 g CO_2 (95% CI 166 to 268 g CO_2). 2. Waste No results in this study. 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	CO_2 production of single-use trays was only a non-significant 15% greater. However, when modelling the single-use tray with cotton and paper the CO_2 production increased notably. For the reusable tray, the washing process contributes most to the total impact. For the disposable tray this is the production process of the polyurethane tray. For the cotton gauzes and paper towel, the production of the gauzes has the greatest impact.	Authors conclusion The author concludes that financial and environmental savings of a hospital converting to reusable trays are important, and that it seems difficult to justify persisting with single-use drug trays, particularly with added cotton gauze. Limitations study Data were average industry data and not directly measured (as with most LCA models). Data from tray manufacturers were unavailable, therefore data of average manufacturing effects were used. For the single-use trays the European energy mix is used, however the Chinese energy mix might be more coal reliant.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
			contributions and lifecycle stages not totally clear. Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: No Uncertainty analysis: Yes, Monte Carlo analysis. Variance analysis: No				
McPherson (2019)	PeerJ Journal information: The open access journal for life and environment Critical review: Peer reviewed journal, not a specific LCA journal and not mentioned in scope. However focus on environment in this journal.	Type of study: LCA Objective: To assess the climate impacts of two different sharps container systems (disposable and reusable) over a 12 month period at Loma Linda University Health in California, USA, which is located considerably further away from manufacturers and reprocessors than is Northwestern Memorial Hospital (previously studied). LCA-method: Attributional LCA Setting and country: Hospital USA Facility: Loma Linda University Health, San Bernardino, CA, USA Years of data collection: - Surgical discipline(s): Nonspecific	Goal and scope[1]: To compare the climate impacts of two different sharps container systems over a 12 month period. Functional unit(s)[2]: Provision of sharps containers at one healthcare facility for one year System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Capital machinery and infrastructure, vehicles, labor, sharps container contents, as well as any inputs and outputs that constituted less than 1% or the systems total mass or energy (article cites "British Standards Institute, 2011 " PAS2050 guide) Inventory database: GaBi Allocation: No Normalization & Weighting: Yes, results	This study followed a very similar methodology as that by Grimmond et al., 2012, including the use of the same cradle-to-grave LCI and calculation tool. The disposable sharps containment system was assessed for a 12 month period prior to Loma Linda University Health's (LLUH) transition to a reusable-based system. The reusable system (certified for 500 uses) was assessed for another 12 month period two years later once the transition was complete. Data were directly collected from LLUH regarding size, type, and number of containers used, as well as changeout protocols. Disposable sharps containers (DSCs) were made from US-sourced polymer in Illinois, packaged in cardboard, transported 3,200km to LLUH, and autoclaved and landfilled in California post-use. Reusable sharps containers (RSCs) were made in Michigan from Korean-sourced polymer, transported 3,500km in	1. Climate Change Annual greenhouse gas (GHG) emissions resulted in a Global Warming Potential (GWP) of 248.62 metric tons of (MT) CO_2 equivalents for DSC and 86.19 $MTCO_2$ equivalents for reusable sharps containers (RSC). Adjusted patient days (APD) were used as the workload indicator to which results were normalized. This resulted in 8.37 $MTCO_2$ equivalents per 10,000 APD for DSC and 2.90 $MTCO_2$ equivalents per 10,000 APD for RSC. Use of RSC reduces GWP by 162.4 $MTCO_2eq$ (65.3%, $P<0.001$, RR 2.27-3.71). 2. Waste Annual waste for DSC resulted in 31.8 tonnes of landfilled plastic, 18.8 tonnes of incinerated plastic and 8.2 tonnes of cardboard boxes for 48,460 manufactured and 35,925 landfilled DSC (chemotherapy DSC were incinerated). Whereas RSC only caused 0.4 tonnes of plastic waste (Tonnes of chemo/pharma DSC incinerated; 412 chemo DSC were used during RSC year) and 0.1 kg of waste from carboard boxes (this were the chemotherapy DSC, which were	Use of RSC leads to reduction of GWP and waste. The manufacturing process is the biggest contributor in GWP for DSC, and thereby gives the largest difference between the two systems. It is predominantly a function of the energy required for the higher total polymer weight needed to be annually manufactured and molded for DSC. Transport is the biggest contributor for RSC. Although more DSC required transportation, the daily transport of RSC resulted in similar GHG over the year between RSC and DSC. The sensitivity analysis revealed variations in RSC lifespan contributed little to the GHG result. It showed that differing electricity sources can alter the GHG contribution of the manufacturing process. It can alter DSC GHG by 23% and RSC GHG	Authors conclusion Large RSC transport distances less the differential between DSC and RSC GHG, however RSC still achieved significant GHG reductions over DSC. Transport and electricity cleanliness are key. RSC lifespan has minimal effect on GHG emissions. Purchasing decisions can contribute to reduction strategies. Institution wide adoption of RSC can reduce GHG with minimal staff behavior change. Limitations study A limitation was the assumption made in the location of the polymer manufacturer for DSC. It was assumed to be close to the DSC manufacturer. Second, the use of the UK database for transport (because it used tonne.km).

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
		Funding and conflict of interest: Brett McPherson and Mihray Sharip declare no conflict of interest. Terry Grimmond is an international consultant in sharps injury prevention and waste management to healthcare and associated industries. Daniels Health, the manufacturer did not review, sight or have input into the design, content, methodology, results, write-up of the study or choice of journal for publication. Daniels Health granted $2500 towards the cost of the study, which covered approximately 10% of expenses. No other grant or funding was received from any funding agency in the public, commercial, or not-for-profit sectors. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.	normalised to 10,000 Adjusted Patient Days Impacts reported: Yes Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes, reducing reusable container lifespan, alternate electricity grids, reprocessing optimization. Uncertainty analysis: No Variance analysis: Yes	reusable transport containers, and reprocessed in California 440km from LLUH. Instead of normalizing the results to occupied beds, as was the case in Grimmond et al., 2012, total 'Adjusted Patient Days' was instead used as the workload indicator to which results were normalized. Characterization methods: IPCC	used in both systems if there was an indication for chemotherapy). In total 3195 RSC were manufactured and 0 containers were landfilled (all parts were either reused or recycled). 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	by 10%. RSC reprocessing accounted for 5.6% of the RSC life cycle. Material reclamation could reduce DSC life cycle GHG.	
Vozzola (2018)	PDA Journal of Pharmaceutical Science an Technology Journal information PDA JPST is the primary source of peer-reviewed scientific and technical papers on topics related to pharmaceutical/biopharm	Type of study: LCA Objective: To assess the environmental impacts of two different cleanroom coveralls: reusable and disposable	Goal and scope[1]: To compare market representative reusable versus disposable cleanroom coveralls (defined as a single-piece, long-sleeve extra-large (XL) zip up garment). The scope was cradle to end of life.	An LCA was conducted to assess the environmental impacts of two different cleanroom coveralls: reusable and disposable. This study is an analysis from cradle to crave, quantifying parameters such as energy use and GHG emissions, including	1. Climate Change The CO_2 footprint of reusable coveralls resulted in 517 kg CO_2 equivalents for 1000 uses. The disposable (HDPE) resulted in 712 kg CO_2 equivalents and the disposable (PP) in 1220 kg CO_2 equivalents per 1000 uses.	The reusable coveralls have a lower environmental impact and produce less waste compared to the disposable variant. The biggest contributor in CO_2 footprint for the disposable coverall is the	Authors conclusion It is absolutely clear that the environmental benefit of reusable coveralls is significant. Limitations study Packaging materials vary between supply companies and in this

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	aceutical manufacturing, sterile product production, aseptic processing, pharmaceutical microbiology, quality, packaging science, and other topics relevant to PDA members. PDA JPST is an internationally recognized source that receives over a quarter of a million visitors annually. Critical review: Peer reviewed journal, not a specific LCA journal and not mentioned in scope. For this study, only a 'portion' of the LCI data were reviewed externally by industry experts. The report was internally reviewed by four members of the commissioning body	LCA-method: Attributional LCA Setting and country: USA Facility: - Years of data collection: - Surgical discipline(s): Nonspecific Funding and conflict of interest: The European Change Consortium (partners of the consortium include drape and tape industry groups) commissioned Environmental Clarity, Inc to undertake the LCA	Functional unit(s)[2]: 1,000 garment uses System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: The collection and reuse activities and credits were outside of the boundary of this study. The eventual landfill activities were also outside of the boundary of this study. Inventory database: Environmental Clarity Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes, only for NRE consumption and GHG emissions. Scenario analysis: Yes, different transportation scenarios. Comparative analysis: Yes Sensitivity analysis: No Uncertainty analysis: No Variance analysis: No	different phases: Raw material extraction, production, packaging, transport, reuse and disposal. Characterization methods: -	Switching to reusable resulted in a 27-58% decrease of the carbon footprint. For the disposable HDPE and PP coverall the manufacturing process contributed most to the CO_2 footprint (resp. 414 kg CO_2eq and 823 kg CO_2eq, 58-68% of cradle to end of life GHG). For the reusable PET coverall this resulted in 115 kg CO_2eq (22% of cradle to end of life GHG) The packaging manufacturing contributed for the reusable PET 4.4 % (22.8 kg CO_2eq) of the cradle to end of life GHG, for the disposable HDPE 6.8% (48.4 kg CO_2eq) and for the disposable PP 4% (48.4 kg CO_2eq). The laundry process contributed for the reusable PET 65 % (336 kg CO_2eq) of the cradle to end of life GHG, for the disposable HDPE 20% (143 kg CO_2eq) and for the disposable PP 17% (204 kg CO_2eq). The sterilization process contributed for the reusable PET 0.21% (1.08 kg CO_2eq) of the cradle to end of life GHG, for the disposable HDPE 0.065% (0.461kg CO_2eq) and for the disposable PP 0.054% (0.657 kg CO_2eq). The use phase transport contributed for the reusable PET 8.1% (42.1 kg CO_2eq) of the cradle to end of life GHG, for the disposable HDPE 14% (99.9 kg	manufacturing process (58-68%). For the reusable variant this is the laundry process (65%).	study representative materials are used for the different companies, however these are not precisely defined per company.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					CO_2eq) and for the disposable PP 11% (132 kg CO_2eq). The End-of-Life contributed for the reusable PET 0% (0 kg CO_2eq) of the cradle to end of life GHG, for the disposable HDPE 0.87% (6.19 kg CO_2eq) and for the disposable PP 8.35% (0.69 kg CO_2eq). 2. <u>Waste</u> Solid waste includes: Disposable coveralls, biological waste, and plastic and paper packaging. In this study, 100% of the reusable cleanroom coveralls were reused in other industries at the end-of-life stage and therefore not included as solid waste. The waste generation of reusable coveralls resulted in 10.2 kg for 1000 uses. The disposable (HDPE) resulted in 171 kg and the disposable (PP) in 238 kg per 1000 uses. 3. <u>Acidification</u> No results in this study. 4. <u>Eutrophication</u> No results in this study. 5. <u>Human Toxicity</u> No results in this study. 6. <u>Ecotoxicity</u> No results in this study. 7. <u>Ozone Depletion</u> No results in this study.		
Vozzola (2018)	American Journal of Infection Control (AJIC)	<u>Type of study:</u> LCA	<u>Goal and scope[1]:</u>	An LCA was conducted to assess the environmental	1. <u>Climate change</u>	The reusable isolation gowns have a lower	<u>Authors conclusion</u>

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	Journal information AJIC covers key topics and issues in infection control and epidemiology. Infection control professionals, including physicians, nurses, and epidemiologists, rely on AJIC for peer-reviewed articles covering clinical topics as well as original research. Critical review: Peer reviewed journal, not a specific LCA journal and not mentioned in scope.	Objective: To assess the environmental impacts of two different isolation gowns: reusable and disposable LCA-method: Attributional LCA Setting and country: USA Facility: - Years of data collection: - Surgical discipline(s): Nonspecific Funding and conflict of interest: The American Reusable Textile Association (ARTA) and International Association for Healthcare Textile Management (IAHTM) committees with reusable and disposable firms were essential in providing funding and field information for this study.	(1) to compare 4 environmental impacts (energy, global warming potential, water use, and solid waste consumption) of reusable and disposable isolation gowns; (2) to clearly show what parts of the life cycle are important to the result; and (3) to provide a sensitivity analysis for important parameters. Functional unit(s)[2]: 1,000 isolation gown uses System boundaries: Cradle to grave Included stages: Resource extraction, gown manufacture, gown use and/or reuse in healthcare settings, to end-of-life disposal. Stated excluded components: The study did not include other medical textiles used in healthcare settings such as gloves, wipes, or masks. Inventory database: Environmental Clarity Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes Scenario analysis: Yes Comparative analysis: Yes	impacts of two different isolation gowns: reusable and disposable. The functional unit was 1000 isolation gowns uses. This study is an analysis from cradle to grave including manufacturing, use and end-of-life stages of the gown systems. The Environmental Clarity, Inc. LCA database was used to evaluate the life cycles of both isolation gown systems. Sixteen disposable isolations gowns from 5 suppliers were studied, composed primarily of nonwoven polypropylene fabric. Eight reusable isolation gowns were studied, composed of primarily woven polyester fabric. The outcome measures were climate change and waste. Characterization methods: -	The CO_2 footprint of reusable isolation gowns resulted in 218 kg CO_2 equivalents for 1000 uses. The disposable resulted in 310 kg CO_2 equivalents per 1000 uses. Switching to reusable resulted in a 30% decrease of the carbon footprint. For the disposable isolation gowns the manufacturing process contributed most to the carbon footprint (accounting for 97% of the energy consumption and global warming potential and 100% of the blue water consumption). The laundry steps had a large influence on the environmental indicators for reusable isolation gowns, accounting for 68% of energy consumption, 67% of greenhouse gas emissions, and 20% of blue water consumption. Nevertheless, the reduction in environmental impact achieved by producing fewer gowns (when using reusables) outweighed the added load imposed by the laundering process of reusables.	environmental impact and produce less waste compared to the disposable variant. The biggest contributor in CO_2 footprint for the disposable coverall is the manufacturing process. For the reusable variant this is the laundry process.	This analysis, combined with agreement of previous partial life cycle studies of other medical textiles, makes it absolutely clear that the environmental benefit of reusable isolation gowns is significant. Limitations study Funding could potentially be a source of bias. Different energy mixes are not taken into account, this potentially limits the representativeness of the results for other parts of the world. A sensitivity analysis is conducted, however results are not shown.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
			Sensitivity analysis: Yes, it is stated that it has been done, however results are not clear. Uncertainty analysis: No Variance analysis: No		2. Waste The amount of solid waste of reusable isolation gowns resulted in 0.413-4.42 kg for 1000 uses (range based on 0-100% reuse in other industries after disposal). The disposable resulted in 63.4 kg per 1000 uses. Switching to reusable resulted in at least a 93% decrease of solid waste.		
Vozzola (2020)	AORN Journal Journal information The AORN Journal will be an indispensable resource recognized for scholarly, evidence-based, peer-reviewed articles that convey standards of excellence and innovations in the delivery of perioperative nursing. Journal content supports the clinical, research/quality improvement, education, and management strategies related to the nurse's role in caring for patients before, during, or after operative and other invasive and interventional procedures in ambulatory and inpatient settings. Critical review: Peer-reviewed, however no specific LCA journal or	Type of study: LCA Objective: To assess the environmental impacts of two types of surgical gown: disposable and reusable LCA-method: Attributional LCA Setting and country: USA Facility: - Years of data collection: - Surgical discipline(s): Nonspecific Funding and conflict of interest: All authors declare affiliations that could be perceived as posing a	Goal and scope[1]: Assessment of environmental impacts of disposable versus reusable surgical gowns. Functional unit(s)[2]: 1,000 uses of an extra large, single-piece, long-sleeved surgical gown in an operating room setting System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, use, reuse, disposal Stated excluded components: - Inventory database: Environmental Clarity Inc. Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes Scenario analysis: No Comparative analysis: No	LCA of reusable versus disposable gowns to assess the environmental impact of these surgical gowns in the USA. An LCA was conducted according to the standards from the International Organization for Standardization. The Environmental Clarity, Inc, LCA database was used to evaluate the life cycles of both surgical gown systems. The outcome Climate Change was expressed as GWP, in kg of CO2 equivalents. Characterization methods: -	1. Climate Change The total GWP for 1,000 uses of the reusable surgical gown is 557 kg CO_2eq, and for the disposable 1636 kg CO_2eq. By selecting the reusable surgical gown, this will result in a 66% reduction of GWP. The gown manufacturing and supply chain resulted for 1,000 uses of the reusable gown in 134 kg CO_2eq and for the disposable gown 1495 kg CO_2eq. The packaging manufacturing and supply chain resulted for 1,000 uses of the reusable gown in 76.7 kg CO_2eq and for the disposable gown in 121 kg CO_2eq. Laundry resulted in 278 kg CO_2eq for the reusable gown, and there was 0 kg CO_2eq used for the disposable gowns. The sterilization of the gowns resulted in 19.8 kg CO_2eq for the	The reusable surgical gown has lesser impact on the environment in terms of Climate Change and waste. The biggest contributor for the disposable gown is the manufacturing process, as well for the GWP as in waste production. For the reusable surgical gown the laundry phase has the greatest impact.	Authors conclusion The current study adds to the body of evidence that shows the environmental superiority of reusable surgical gowns. Limitations study Comfort was not taken into the analysis, although this is a factor for scrubbed surgical team members. Economic measurements are not included. The blue water comparisons' accuracy is limited due to lack of data on water content of soiled gowns. Not all disposable gowns are produced in Chine or sterilized with ethylene oxide (what is used in this study).

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	LCA taken into the scope of the journal.	potential conflict of interest (all authors are consultants for the American Reusable Textile Association and the International Association for Healthcare Textiles, and are involved in Environmental Clarity, Inc.) This study was funded by The American Reusable Textile Association (ARTA) Life Cycle Assessment Committee, Shawnee Mission, KS.	Sensitivity analysis: Yes, modelled 0% and 100% reuse of end-of-life reusable gowns in other industries; if disposable gowns were instead manufactured in the US, 10% more energy efficient laundry processes. Uncertainty analysis: No Variance analysis: No		reusable and 6.26 kg CO_2eq for the disposable gown. The use phase transport of 1,000 reusable gowns resulted in 38.7 kg CO_2eq for the reusable gown and 2.47 kg CO_2eq for the disposable gown. The end of life contribution to the GWP resulted in 1.40 kg CO_2eq for the reusable variant and 10.9 kg CO_2eq for the disposables. 2. Waste Solid waste per 1,000 uses/1,000 gowns resulted in 35.5-43.4 kg for the reusable and 265 kg for the disposable gown. Gown manufacturing resulted in 0-7.9 kg solid waste for the reusable and 224 kg solid waste for the disposable gown (1,000 uses/gowns). Packaging manufacturing and supply chain yielded 35.5 kg solid waste for the reusable gown and 40.3 kg for the disposable (1,000 uses/gowns). End of life resulted in 0-0.00842 kg solid waste for the reusable and 0.505 for disposable gowns (1,000 uses/gowns). 3. Acidification No results in this study. 4. Eutrophication No results in this study.		Packaging of disposable and reusables vary.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.		
Davis (2018)	Journal of Endourology Journal information Peer-reviewed journal and innovative videojournal companion exclusively focused on minimally invasive and robotic urology, applications, and clinical outcomes. Critical review: Peer reviewed article. Not in specific LCA journal.	Type of study: LCA Objective: To assess the climate impacts of two types of flexible ureteroscopes: single-use (LithoVue™, Boston Scientific) and reusable (Olympus Flexible Video; typically 16 uses before repair and 180 uses before decommissioning) LCA-method: Attributional LCA Setting and country: Hospital Australia Facility: Austin Hospital, Melbourne, Victoria, Australia Years of data collection: - Surgical discipline(s): Urology & Nephrology Funding and conflict of interest: -	Goal and scope[1]: To compare the environmental impacts of single-use and reusable ureteroscopes. Functional unit(s)[2]: Use of one ureteroscope during one endourologic case System boundaries: Cradle to grave Included stages: Raw material extraction, production, reuse, disposal Stated excluded components: - Inventory database: - Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: No Uncertainty analysis: No Variance analysis: No	The environmental impact of single-use flexible ureteroscopes with reusable flexible ureteroscopes were compared. An LCA of the LithoVue (Boston Scientific) single-use digital flexible ureteroscope and Olympus Flexible Video Ureteroscope (URV-F) was performed. Data on raw material extraction, manufacturing, reuse and disposal of the instruments was obtained. The solid waste generated (kg) and energy consumed (kWh) during each case were quantified and used to calculate the CO2 footprint. The outcome measures were Climate Change (CO2 footprint) and waste. Characterization methods: -	1. Climate Change The CO_2 footprint per case was calculated. For the single-use ureteroscope the total CO_2 footprint per case is 4.43 kg CO_2 equivalents. This consisted of manufacturing costs, solid waste and sterilization. The manufacturing costs resulted in 3.83 kg CO_2, solid waste in 0.3 kg CO_2 and sterilization 0.3 kg CO_2. The total CO_2 footprint of the reusable ureteroscope was 4.47 kg CO_2 per case. This consisted of manufacturing costs (0.06 kg CO_2), washing/sterilization (3.95 kg CO_2), repackaging theatre wrap (<0.005 kg CO_2), repair costs (0.45 kg CO_2) and solid waste (0.005 kg CO_2). 2. Waste Solid waste for the disposable ureteroscope resulted in 0.3 kg CO_2 per case. Solid waste for the reusable ureteroscope resulted in 0.005 kg CO_2 per case. 3. Acidification No results in this study. 4. Eutrophication No results in this study.	The study suggests the data on environmental costs are comparable between the disposable and reusable ureteroscope. However, the comparison is per case and not for the whole life cycle of a reusable ureteroscope, so this might interfere with the results. It is expected that with the high manufacturing impact of the disposable variant, this impact after multiple uses will exceed the environmental impact of the reusable variant.	Authors conclusion The carbon footprint of the single use and reusable ureteroscopes is comparable. Informed clinicians should be willing to advocate for changes within the healthcare delivery and within the manufacturing industry to maintain healthcare quality, cost-effectiveness and safety in the future. Limitations study The data are compared per case. However, reusable ureteroscopes can be used multiple times. This is not included in the analysis and could potentially lead to a lower environmental impact for reusable ureteroscopes.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.		
Donahue (2020)	American Journal of Obstetrics & Gynecology Journal information The American Journal of Obstetrics and Gynecology, “The Gray Journal”, covers the full spectrum of Obstetrics and Gynecology. The aim of the Journal is to publish original research (clinical and translational), reviews, opinions, video clips, podcasts and interviews that will have an impact on the understanding of health and disease and that has the potential to change the practice of women's health care. An important focus is the diagnosis, treatment, prediction and prevention of obstetrical and gynecological disorders. The Journal also publishes work on the biology of reproduction, and content which provides insight into the physiology and mechanisms of obstetrical	Type of study: LCA Objective: To assess the climate impacts of three types of vaginal specula that are commonly used in practice (a single-use acrylic model and two reusable stainless steel models) LCA-method: Attributional LCA Setting and country: USA Facility: Michigan Medicine, University of Michigan, Ann Arbor, MI, USA Years of data collection: - Surgical discipline(s): Obstetrics & Gynecology Funding and conflict of interest: The authors report no conflict of interest.	Goal and scope[1]: To compare the environmental impacts of three types of vaginal specula (one single-use and two reusable models) Functional unit(s)[2]: Completion of 20 gynaecologic examinations using a speculum System boundaries: Cradle to grave Included stages: Raw material extraction, production, transportation, reuse, and disposal Stated excluded components: Excluded components were inks, bulk packaging, autoclave production, illumination pack for plastic specula, and lubrication (expected to have minimal impacts on results). Inventory database: EcoInvent, IDEMAT, GREET, EPA WARM Allocation: No Normalization & Weighting: No Impacts reported: Yes	Life cycle assessment methods were applied to evaluate the carbon footprints of 3 vaginal specula: a single-use acrylic model and two reusable stainless steel models (reusable stainless steel grade 304 speculum and the reusable stainless steel grade 316 speculum). The data were obtained regarding speculum and packaging composition and weight. There were no data available on production processes for the specula. For this reason, assumptions were made. For the acrylic specula injection molding was assumed and for the reusable specula a combination of hot extrusion, milling/turning, deformation and heat treatment was assumed, based on literature. The transportation was based on manufacturer and general industry data. Reuse for the steel reusable specula was estimated based on autoclave manufacturer	1. Climate Change Donahue (2020) demonstrated the reusable grade 304 speculum produces fewer life cycle CO_2e emissions than the equivalent number of disposable acrylic specula after 2 completed examinations (2.11 kg CO_2e compared to 2.63 kg CO_2e). The reusable grade 316 produces fewer life cycle CO_2e emissions after 3 completed examinations (3.11 kg CO_2e compared to 3.51 kg CO_2e). The reusable stainless steel grade 304 speculum is less carbon intensive to produce compared to the grade 316 speculum, which is the reason why the grade 304 remains less in its total life cycle CO_2e emissions over a wide range of uses. After 500 examinations the difference becomes more apparent (grade 316 – 107.52, grade 304 – 101.31 and acrylic – 438.55 kg CO_2e). The contribution of the stages differs between the specula. The largest contributor for the disposable acrylic speculum is material production and manufacturing (90.6%), followed	The study shows the disposable acrylic speculum has the biggest negative environmental impact. This is mainly due to material production and manufacturing. This phase offers opportunities to decrease this impact. For the reusable stainless steel specula the main contributor is the energy used to power autoclaves. Here is an opportunity to reduce this by increasing the efficiency of energy-use and by making a transition to more renewable energy sources. In the sensitivity analysis it became clear that the impact increased significantly when shifting to individually sterilizing the specula, instead of sterilizing multiple at the same time (increase of 189-219%). However, doubling the autoclave load (4 Pouches (base case) to 8 Pouches (full load)) did not have a great difference in the overall	Authors conclusion By using acrylic specula for over a period of 1 year (5875 disposable acrylic specula), 5153 kg CO2e and 5462 kg solid waste were produced. By changing to steel grade 304 of grade 316 specula (100 uses average), greenhouse gas emissions could have been reduced by 75& and 74% respectively with a significant decline in end-of-life waste generation (both 64.43 kg). Health systems might consider environmental impact in addition to costs and clinical efficacy when choosing medical instruments. Limitations study Multiple assumptions were made in the analysis, mainly regarding production and reprocessing, due to lack of data from manufacturers and other sources. The authors choose to use the less carbon intensive approach

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	and gynecological diseases. Critical review: Peer reviewed, not a specific LCA journal.		Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes, Sensitivity analysis reports impacts based on different numbers of uses (1-500), autoclave loading practices, regional electricity grids, reprocessing method (autoclave vs H_2O_2) Uncertainty analysis: No Variance analysis: No	specifications. Disposal was modeled with the use of the EPA WARM model, which estimates the average greenhouse gas (GHG) emissions that are associated with disposal of various materials in the United States (US). Characterization methods: IPCC	by transportation (6.5%) and waste/end-of-life (2.9%). For the reusable stainless steel grade 304 speculum the largest source of CO_2 emissions is use/reprocessing (74.1%), followed by material production and manufacturing (24.9%) and transportation (0.46%). The biggest contributor in total life cycle emissions for the grade 316 speculum was use/reprocessing (65.2%), followed by production (34.4%) and transportation (0.4%). 2. Waste No results in this study. 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	impact (20-39% decrease in greenhouse gas emissions). Changing from the most carbon intensive electricity grid to the least carbon intensive resulted in a 33-36% reduction of CO_2e emissions. Regardless of the grid used, the stainless steel life cycle greenhouse gas emission remained lower than the acrylic specula. Using high level disinfectant instead of autoclave sterilization, resulted in a 11-12% increase in greenhouse gas emissions.	for the acrylic specula and the more carbon intensive approach for the steel specula, to ensure any difference shown would be robust. Next to that, the study was further limited by the lack of life cycle data on high level disinfectants such as glutaraldehyde, ortho-phthalaldehyde and peracetic acid.
Eckelman (2012)	Anesthesia & Analgesia Journal information The "The Global Standard in Anesthesiology," provides practice-oriented, clinical research you need to keep current and provide optimal care to your patients. Brings peer reviewed articles on	Type of study: LCA Objective: To assess the environmental impacts of two types of laryngeal mask airways (LMAs): single-use (Unique™) and reusable (Classic™; 40 lifetime uses)	Goal and scope[1]: Compare the environmental impact of a disposable and a reusable LMA, from cradle to grave. Functional unit(s)[2]: Maintenance of 40 airways System boundaries: Cradle to grave Included stages:	The environmental impacts of two types of laryngeal mask airways (LMAs): single-use (Unique™) and reusable (Classic™; 40 lifetime uses) were assessed by using a life cycle assessment method. Raw material extraction, production, packaging, transport,	1. Climate Change Eckelman (2012) demonstrated the results on climate change specifically to be 7.4 kg CO_2e of GHG over its life cycle for the reusable LMA and 11.3 kg CO_2e for the disposable LMA. For all outcomes in this study, results are expressed in percentages, whereas the LMA with the highest impact is defined as	This study demonstrates the disposable LMA has a bigger environmental impact compared to the reusable LMA. In the outcome measure climate change, this is mainly due to the production of the material for the disposable LMAs that is used. A change of material	Authors conclusion The results suggest the reusable LMA has a lower life cycle environmental impact compared to the disposable LMA at Yale New Haven Hospital, across all categories of concern. Limitations study

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	the latest advances in drugs, preoperative preparation, patient monitoring, pain management, pathophysiology, and many other timely topics. Critical review: Peer reviewed, not a specific LCA journal.	LCA-method: Attributional LCA Setting and country: USA Facility: Yale-New Haven Hospital, New Haven, CT, USA Years of data collection: - Surgical discipline(s): Anesthesiology Funding and conflict of interest: The authors declare no conflict of interest. Funding came from the department of anesthesiology, Yale School of Medicine.	Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Excluded components were bulk packaging, machinery, and small components such as inks and labels on the packaging and on the sterilization indicator strips (expected to have negligible impacts) Inventory database: Ecoinvent Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: No (hotspots reported in text) Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes, tests alternative assumptions including transport mode, autoclave loading, number of reuse cycles (10-100), waste pathways, and labour. Uncertainty analysis: No Variance analysis: No	reuse and disposal were included in the analysis. The material composition and weights were established on the basis of manufacturer information and density testing. Materials were matched with the most appropriate Life Cycle Inventory (LCI) records from EcoInvent (database). Production processes for hard and soft plastics were assumed to be injection molding and thermoforming, respectively. Data was obtained from distributors to estimate distances and mode of transport. Reprocessing of reusable LMAs was estimated using data from Yale New Haven Hospital and autoclave specifications. Disposal was modelled using US average statistics for solid waste. Characterization methods: BEES	100% and the other LMA is relatively compared to the LMA with the highest impact. For the outcome climate change, the disposable LMA had the highest impact (100%) compared to the reusable LMA (65%). The largest source for the disposable LMA is the polymerization of PVC (23%), which is the main material used. The majority of the remaining contributors are polycarbonate production (14%), transportation via truck (15%), thermoforming (13%) and waste disposable (11%). The majority of the GHG emissions for the reusable LMA (77%) is from natural gas production and combustion, which is to produce steam for the autoclave. 2. Waste No results in this study. 3. Acidification For the outcome acidification, the disposable LMA had the highest impact (100%) compared to the reusable LMA (20-30%). 4. Eutrophication For the outcome eutrophication, the disposable LMA had the highest impact (100%) compared to the reusable LMA (90-100%). 5. Human Toxicity The human toxicity, stated as human health (HH) in this study, was defined in three different groups: HH cancer, HH noncancer and HH air	production, or a change in type of material which has a lesser impact on the environment could be a way to help reduce the impact for the disposable LMA. Next to that the biggest contributor for the reusable LMA is the production of steam for the autoclave. If this could be done in some other way, the environmental impact of the reusable LMA could decrease. Alternate assumptions are also made in this study. It shows the effect of alternate modes of transport, compared to the base case (rail), was quite small for the reusable LMA but more interesting for the disposable LMA, leading to a decrease in GHG emissions (-9%) changing to transport by road, and an increase (+81%) by using air transportation. Individually autoclaving the reusable LMA resulted in an increase of life cycle GHG emissions by >400%, whereas loading with 10 LMAs per cycle (compared to the base case 5 per cycle) resulted in a decrease of 25%. Using a more capital intensive option to increase the energy efficiency of the machines by 10% results	This study did not analyse the environmental health impacts during the use of an LMA, where intraoperative exposure to some parts of the plastics could contribute increasing the outcome human toxicity.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					pollutants. For the outcome HH cancer, the disposable LMA had the highest impact (100%) compared to the reusable LMA (0-10%). For the outcome HH noncancer, the disposable LMA had the highest impact (100%) compared to the reusable LMA (0-10%) and the outcome HH air pollutants, resulted in the highest impact for yet the disposable LMA (100%) compared to 20-30% for the reusable LMA. 6. Ecotoxicity For the outcome ecotoxicity, the disposable LMA had the highest impact (100%) compared to the reusable LMA (10-20%). 7. Ozone Depletion For the outcome ozone depletion, the disposable LMA had the highest impact (100%) compared to the reusable LMA (20-30%).	in a decrease of GHG emissions of 8%. The human toxicity impacts are dominated by the production and use of plastics for the disposable LMA. Increasing the amount of PVC by 10% leads to a 5% increase in cancer and noncancer effects. Premature disposal of the reusable LMA has its direct effects on GHG emissions, by a >50% increase if the LMA is disposed at 10 reuse cycles. Extending the reuse cycle of reusable LMAs to 80 cycles (doubling lifetime) results in a decrease of GHG emissions by 9%. In waste management, by switching from 100% incineration to 100% landfill, reduces the impacts across all categories by 5-10%. Including the labor for cleaning impacts (base case not included) resulted only in a nominally increase for total GHG emissions and water impacts of reusable LMAs.	
Ibbotson (2013)	International Journal of Life Cycle Assessment	Type of study: LCA	Goal and scope[1]: Assess the environmental and financial impacts of	The environmental and financial impacts of three surgical scissors which are	1. Climate Change Ibbotson (2013) reported the results on climate change	The study shows that the reusable stainless steel scissor is the choice with	Authors conclusion The eco-efficiency results indicated that the stainless

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	Journal information The International Journal of Life Cycle Assessment is the first journal devoted entirely to Life Cycle Assessment and closely related methods. The Int J Life Cycle Assess is a forum for scientists developing LCA and LCM (Life Cycle Management); LCA and LCM practitioners; managers concerned with environmental aspects of products; governmental environmental agencies responsible for product quality; scientific and industrial societies involved in LCA development, and ecological institutions and bodies. Critical review: Peer reviewed, specific LCA journal.	Objective: To assess the environmental and financial impacts of three types of surgical scissors: disposable plastic reinforced scissors, disposable stainless steel scissors, and reusable stainless steel scissors LCA-method: Attributional LCA Setting and country: Hospital in Germany Facility: - Years of data collection: - Surgical discipline(s): Nonspecific Funding and conflict of interest: -	three surgical scissors, to compare their eco-efficiency. Functional unit(s)[2]: 4,500 use cycles of surgical scissors during 18 years System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: - Inventory database: EcoInvent, Australian Data 2007 Allocation: No Normalization & Weighting: No Impacts reported: Yes, graphically with log scale. Contribution analysis: Only for ReCiPe endpoint and CED results. Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes, tests alternative electricity mixes, sterilization processes (gamma and gas), disposal method (incineration and recycling). Uncertainty analysis: No Variance analysis: No	(1) disposable scissors made of plastic (fibre reinforced), (2) disposable scissors made of stainless steel and (3) reusable scissors made of stainless steel were assessed using a life cycle assessment and life cycle costing method. The data was compared for the use of 4,500 cycles if usage in Germany. The data on raw material, manufacturing (including electricity consumption), transport, and disposal process were obtained from a medical company in Europe. Missing data (e.g. sterilization processes for reusable scissors) were obtained from the literature or expert opinion. Electricity data that was missing was adjusted from the International Energy Agency (IEA). Incineration of plastics, cardboard and municipal solid waste were assumed based on Swiss plants in 2000 (from EcoInvent). Characterization methods: CED Method, ReCiPe	graphically in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. It demonstrates that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 10,000 kg CO_2-equivalents), followed by the disposable plastic scissor (+/- 5500 kg CO_2-equivalents) and eventually the reusable stainless steel scissor (+/- 550 kg CO_2-equivalents). 2. Waste No results in this study. 3. Acidification Ibbotson (2013) reported the results on acidification in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. It demonstrates that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 90 kg SO_2-equivalents), followed by the disposable plastic scissor (+/- 20 kg CO_2-equivalents) and eventually the reusable stainless steel scissor (+/- 0.8 kg SO_2-equivalents). 4. Eutrophication Ibbotson (2013) reported the results on eutrophication in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. Freshwater and	the lowest environmental impact in all the impact categories investigated. This is followed by the disposable plastic scissor and eventually the disposable stainless steel scissor, which has the highest impact. The hotspots for the disposable scissors were found in the material and manufacturing process and for the reusable scissor this was found in the usage phase, which could be appointed to the washing, disinfection and sterilization cycles and the repair and service cycles.	steel reusable scissor is the option with the lowest environmental impact and is next to that, cheapest. Limitations study Data sources were not comparable between the scissors, since the plastic disposable and stainless steel reusable data was obtained from company data and the stainless steel disposable scissor data was obtained from literature. Data on electricity was not available (located in Asian countries), so another energy mix was used. This also accounted for other data like recycling data. This results in a situation that could not be totally applicable for the German situations studied.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					marine eutrophication are described separately. Regarding freshwater eutrophication, the results demonstrate that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 1 kg P-equivalents), followed by the disposable plastic scissor (+/- 0.55 kg P-equivalents) and eventually the reusable stainless steel scissor (+/- 0.3 kg P-equivalents). Next to that, with regard to marine eutrophication, the results demonstrate that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 10 kg N-equivalents), followed by the disposable plastic scissor (+/- 6 kg N-equivalents) and eventually the reusable stainless steel scissor (+/- 0.2 kg N-equivalents). 5. Human Toxicity Ibbotson (2013) reported the results on human toxicity in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. It demonstrates that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 7750 kg 1.4-DB equivalents), followed by the disposable plastic scissor (+/- 750 kg 1.4-DB equivalents) and eventually the reusable stainless steel scissor (+/- 200 kg 1.4-DB equivalents).		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					6. <u>Ecotoxicity</u> Ibbotson (2013) reported the results on ecotoxicity graphically in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. Terrestrial and freshwater ecotoxicity are described separately. Regarding terrestrial ecotoxicity, the results demonstrate that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 2 kg 1.4-DB equivalents), followed by the disposable plastic scissor (+/- 0.4 kg 1.4-DB equivalents) and eventually the reusable stainless steel scissor (+/- 0.03 kg 1.4-DB equivalents). Next to that, with regard to freshwater ecotoxicity, the results demonstrate that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this category (+/- 500 kg 1.4-DB equivalents), followed by the disposable plastic scissor (+/- 55 kg 1.4-DB equivalents) and eventually the reusable stainless steel scissor (+/- 4 kg 1.4-DB equivalents). 7. <u>Ozone Depletion</u> Ibbotson (2013) reported the results on ozone depletion in Figure 4 of the article (Ibbotson, 2013). The figure shows the results on a log scale and the outcomes are extracted from this figure. It demonstrates that after 4,500 use cycles the disposable stainless steel scissor has the highest impact in this		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					category (0.00055 kg CFC-11 equivalents), followed by the disposable plastic scissor (0.0001 kg CFC-11 equivalents) and eventually the reusable stainless steel scissor (+/- 0.00004 kg CFC-11 equivalents).		
Leiden (2020)	Resources, Conservation & Recycling Journal information Open Access journal with independent editorial board and peer-review process. Contributions from research, which consider sustainable management and conservation of resources are welcomed. The journal emphasizes the transformation processes involved in a transition toward more sustainable production and consumption systems. Emphasis is upon technological, economic, institutional and policy aspects of specific resource management practices, such as conservation, recycling and resource substitution, and of "systems-wide" strategies, such as resource productivity improvement, the restructuring of production and consumption profiles and the transformation of industry.	Type of study: LCA Objective: To assess the environmental impacts of two types of instrument set for single-level lumbar fusion surgeries: disposable (Neo Pedicle Screw System from Neo Medical SA) and reusable (Viper 2 from DePuy Synthes, 300 uses). LCA-method: Attributional LCA Setting and country: Hospitals in Germany Facility: - Years of data collection: - Surgical discipline(s): Neurology Funding and conflict of interest: The study was funded by Neo Medical S.A., but it is stated that Neo Medical S.A. had no direct	Goal and scope[1]: To compare whether reusable or disposable surgical instrument sets for single-level lumbar fusion surgeries are advantageous from an environmental perspective. Also, the identification of hotspots for designing future sustainable surgical instruments. Functional unit(s)[2]: The surgical instrument set required for one single-level lumbar fusion surgery involving the implantation of four screws and two rods System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: - Inventory database: EcoInvent Allocation: No Normalization & Weighting: No Impacts reported: No Contribution analysis: Yes Scenario analysis: No	The difference in contribution to the environmental impact of a disposable and a reusable surgery instrument set for lumbar fusion surgeries are investigated. The data compares the reusable and the disposable set for one single surgery in Germany. The data on manufacturing was based on weight, material and form of instruments, transportation on mode and calculated distances between producer, distributor, and hospital and washing and steam sterilization was specific to a German hospital. Disposal was modelled using EcoInvent waste incineration processes. Characterization methods: CML, ReCiPe	1. Climate Change Leiden (2020) reported the results in percentages. They are displayed as percentage of the maximum value of each impact category. For the outcome climate change, the reusable set had the highest impact (100%) compared to the disposable set (10-20%) after 1 surgery. For the disposable surgical set the production phase had the biggest contribution and for the reusable set the sterilization process. 2. Waste No results in this study. 3. Acidification Leiden (2020) reported the results in percentages. They are displayed as percentage of the maximum value of each impact category. For the outcome climate Acidification, the reusable set had the highest impact (100%) compared to the disposable set (30-40%) after 1 surgery. For the disposable surgical set the production phase had the biggest contribution and for the reusable set the sterilization process. 4. Eutrophication	This study suggests the reusable surgical set has a bigger environmental impact compared to the disposable set. The limitation is that the disposable and reusable set are compared for 1 surgery. Since the reusable set can be reused for several times, this can influence the results over time. A sensitivity analysis has be conducted, where the reusable set has been reused. However, it is still compared to the base case of the disposable set (1 surgery). This does not reflect reality in the results. The biggest hotspots are clearly stated. The sterilization process is the biggest contributor to the environmental impact for the reusable set and for the disposable set the production process is most contributory.	Authors conclusion The authors conclude the environmental impact of the disposable system was significantly lower in all impact categories. This is mainly due to the high impact of the steam sterilization process and the big size of the reusable instruments sets. Limitations study A limitation is that the disposable and reusable set are compared for 1 surgery. Since the reusable set can be reused for several times, this can influence the results over time. A sensitivity analysis has be conducted, where the reusable set has been reused. However, it is still compared to the base case of the disposable set (1 surgery). This does not reflect reality in the results.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	Critical review: Peer reviewed, not a specific LCA journal.	influence on the results of the study.	Comparative analysis: Yes Sensitivity analysis: Yes, tests alternate assumption, including: number of usage cycles for the reusable set (300-500) and loan (distributor rechecks and replaces missing components between each use) vs. consignment system (i.e. in-hospital reprocessing with requests to distributor for missing components) Uncertainty analysis: No Variance analysis: No		No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.		
McGain (2012)	Anesthesia & Analgesia Journal information The "The Global Standard in Anesthesiology," provides practice-oriented, clinical research you need to keep current and provide optimal care to your patients. Brings peer reviewed articles on the latest advances in drugs, preoperative preparation, patient monitoring, pain management, pathophysiology, and many other timely topics. Critical review: Peer reviewed, not a specific LCA journal.	Type of study: LCA Objective: To assess the environmental and financial impacts of two types of central venous catheter insertion kits: single-use and reusable LCA-method: Attributional LCA Setting and country: Hospital in Australia Facility: Western Health, Melbourne, Victoria, Australia Years of data collection: - Surgical discipline(s): Anaesthesia	Goal and scope[1]: To compare the financial costs and environmental impacts of the life cycles of reusable and single-use venous catheter insertion kits and what effect the source of electricity has on the CO_2 emissions. Functional unit(s)[2]: Use of one central venous catheter kit to aid insertion of a single-use, central venous catheter in an operating room. System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Existing equipment (e.g. washers and sterilizers) were not included; Cotton gauze and antiseptic were	McGain (2012) assessed the environmental and financial impacts of two type of central venous catheter insertion kits (single-use and disposable) at the Western Health group of hospitals in Melbourne, Victoria, Australia. Next to the environmental and financial impacts, they investigated the effect of the source of electricity upon CO_2 emissions. The functional unit was the use of one central venous catheter kit to aid insertion of a single-use, central venous catheter in an operating room. Data on the components of the central venous catheter kits was obtained by weighing with an electronic balance and receiving data from the	1. Climate Change McGain (2012) described the results on climate change. One reusable kit produced 1211 grams of CO_2 in total and one disposable kit 407 grams of CO_2. There is no comparison of multiple usage of the reusable kit. The biggest contributor for the reusable kit is the washing and sterilization process (256 resp. 830 grams of CO_2), whereas for the single-use kit this is the plastic used (284 grams of CO_2). A sensitivity analysis showed the influence of different energy mixes on the outcome for the reusable kit, with a Monte Carlo analysis to calculate confidence intervals (CI). Using a brown coal energy mix for the reusable kit resulted in 1211 (95% CI 1099-1323) grams of CO_2 emissions, hospital gas cogeneration in 436 (95% CI 410-473) grams of CO_2 emissions, United States	The environmental and financial impacts of two type of central venous catheter insertion kits (single-use and disposable) are assessed. The results show the reusable kit has a bigger environmental impact compared to the disposable kit. However, this is calculated for one use of each kit. Reusing the reusable kit could influence results. The biggest contributor for the reusable kit is the washing and sterilization process. whereas for the single-use kit this is the use of plastic. The washing and sterilization process could be a hotspot to minimalize the impact, as well as for the disposable kit a different source of	Authors conclusion For hospitals using coal-fired electricity, the environmental effects are greater when using reusable kits instead of single-use. Reducing the environmental impact of the reusable kit is possible by focusing on the inefficiencies and energy sources of steam sterilizers. Limitations study A limitation of the study could be that the reusable insertion kit is compared to the disposable for one use of inserting the single-use central venous catheter. Reusable kits were assumed to have lifespan of 300 uses (metal components requiring sharpening every 100 uses) based on a

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
		Funding and conflict of interest: The authors declare no conflict of interest. They received funding through grants from the Australian and New Zealand Intensive Care Society and Sustainability Victoria.	not included ("because they were common to insertion of all central venous catheters") Inventory database: EcoInvent Allocation: No Normalization & Weighting: No Impacts reported: Yes, only GWP and water use impacts reported, impacts from other categories determined to be 'similar or of minor importance' Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes, tests altered electricity source for the reusable kit: brown coal (base case), gas cogeneration, American standard supply, European standard supply Uncertainty analysis: Yes, Monte Carlo analysis Variance analysis: No	manufacturer. Direct data regarding materials and energy required to reprocess reusable kits (i.e. from the washer and sterilizer) were collected using a "time-in-motion" study. Most other inputs were acquired from LCI databases or industry data. Electricity requirements (kWh) and volumes of hot (gas heated) and cold water used by the washer and sterilizer were measured. Data on waste disposal processes were obtained indirectly from industry data (sodium hypochlorite or incineration). Characterization methods: -	electricity mix in 764 (95% CI 509-1174) grams of CO_2 emissions and a European electricity mix in 572 (95% CI 470-713) grams of CO_2 emissions. 2. Waste No results in this study. 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	material could be of great value.	conservative estimate from staff within the study hospital's sterile supplies department, however this seems not to be included in the analysis. Calculating the difference between the outcomes when reusing this kit is not taken into account and could yet obtain more accurate results.
McGain (2017)	British Journal of Anaesthesia Journal information The British Journal of Anaesthesia (BJA) publishes high-impact original work in all branches of anaesthesia, critical care medicine, pain medicine and perioperative medicine including fundamental, translational and clinical	Type of study: LCA Objective: To assess environmental and financial impacts of reusable and single-use anesthetic equipment. LCA-method: Consequential LCA Setting and country: Hospitals in Australia	Goal and scope[1]: To compare the consequences from changing from one pattern of equipment to another (single-use/reusable), looking whether new labour would be required or where the next kilowatt hour of electricity would be sourced from. Thereby the environmental and financial consequences were defined.	McGain (2017) assessed environmental and financial impacts of reusable and single-use anesthetic equipment through the exploration of 2 base cases and 3 modelled scenarios using a consequential LCA approach. The first base case was situated at a hospital in Melbourne, Australia with "mainly single-use" anesthetic	1. Climate Change McGain (2017) described the five scenarios as following: (1) completely reusable, (2) mainly single-use except for reusable laryngoscope handles, (3) completely single-use (4) reusables (except the single-use face masks), (5) reusables (except single-use laryngoscope blades) in an Australian hospital. Using reusables (scenario 1) had a higher impact [5575 kg CO_2 equivalents (95% CI 5542-5608)]	The results of this study result in a clear overview on how environmental impacts of the same type of equipment (e.g. reusable) can vary between different continents. Where the single-use equipment seem to have a lower environmental impact in Australia, the results suggest the impact is lower in the USA, UK and	Authors conclusion The financial and environmental impact of anaesthetic equipment are investigated. Using single-use equipment costs more than using reusables, in all scenarios. Converting from single-use to reusable leads to an increase in CO_2 emissions of almost 10%, where it decreases when converting in the US (50%) and UK/Europe (85%).

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	sciences, clinical practice, technology, education and training. In addition, the Journal publishes review articles, important case reports, correspondence and special articles of general interest. Critical review: Peer reviewed, not a specific LCA journal.	Facility: Western Health, Melbourne, Victoria, Australia Years of data collection: - Surgical discipline(s): Anaesthesia Funding and conflict of interest: The authors declare no conflict of interest. They received funding for the project from the Australian and New Zealand College of anesthetists (project grant 13/025)	Functional unit(s)[2]: Use of breathing circuits, face masks, LMAs, and direct and videolaryngoscopes at one hospital over one year System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, reuse, disposal Stated excluded components: Existing oil, gas, mining, energy, and transport infrastructure was not included; Maintenance and depreciation of washers and sterilizers were not included ("these would be unaltered by the presence or absence of reusable anesthetic equipment") Inventory database: EcoInvent Allocation: No Normalization & Weighting: Yes, results were normalized to average annual per capita environmental impacts in Australia. Impacts reported: Yes Contribution analysis: No Scenario analysis: Yes Comparative analysis: Yes Sensitivity analysis: No Uncertainty analysis: Yes, Monte Carlo analysis Variance analysis: No	equipment (reusable anesthetic circuits, face masks, 'Proseal'VR (Teleflex, Westneath, Ireland) LMAs, and direct and videolaryngoscope blades and handles. The second base case was situated at another hospital in Melbourne, Australia with "mainly single-use" anesthetic equipment (disposable anesthetic circuits, single-use face masks, LMAs, and direct laryngoscope blades, but using reusable direct laryngoscope handles and reusable videolaryngoscopes). The five scenarios included: "completely single-use", "reusables except for single-use face masks", "reusables except for single-use laryngoscope blades", "reusables (Europe)", "reusables (USA)". Data on equipment were obtained from two hospitals in Melbourne, Australia in 2015 and each piece of equipment was weighed with an electronic balance (accurate to within 1g). Sterilization records and input from senior Central Sterile and Supply Department staff at hospital 1 were used to define sterilization mode and load information. Washer and steam sterilizer utility usage data	compared to using mainly single use [scenario 2; 5095 kg CO_2 equivalents (95% CI 4614-5658)]. For the reusable approach (4807 kg CO_2 equivalents (86%)) was for washer electricity and 387 kg CO_2 equivalents (7%) for H_2O_2 sterilizer electricity, with all other contributing for 381 kg CO_2 equivalents (7%). For scenario 2 (mainly single-use), the majority of the CO_2 emissions (2695 kg CO_2 equivalents, 52%) was for purchasing single use face masks (n=9900) and 1396 kg CO_2 equivalents (27%) for the single-use direct laryngoscope blades (n=9900) and all other items contributed for 1052 kg CO_2 equivalents (21%). Scenario 3 resulted in 5775 kg CO_2 equivalents. Scenarios 4 and 5 led to 6556 and 6763 kg CO_2 equivalents emissions respectively, because 365 and 550 washer loads, respectively, remained. The substitution of one reusable with a single-use item (Scenarios 4 and 5) led to higher CO_2 emissions than either completely reusable or single-use equipment (Scenarios 1–3). An analysis was performed to model results as if the hospital was based in UK/Europe. This led to different results compared to when the hospital was based in Australia. By switching from single-use (5095 kg CO2 equivalents) to reusable anaesthetic equipment, this would have led in a decrease of	in Europe. This is due to the energy mix used in the different continents. In Australia the impact of single-use equipment is lower compared to the other continents, where it is beneficial for the environment to use the reusable anaesthetic equipment.	Limitations study Sterilization records and input from senior Central Sterile and Supply Department staff at hospital 1 were used to define sterilization mode and load information, when 2 hospitals were involved. Comparing or using data from both hospitals would have been more accurate. This also accounts for electricity consumption of the sterilizer.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
				were taken from a previous study by the same authors (0.15 kWh and 40 litres of water per kg of anesthetic equipment steam sterilized), while electricity consumption of a standard H2O2 sterilizer was directly measured over several days at hospital 1. <u>Characterization methods:</u> -	84% (802 kg CO2 equivalents). This can be explained by the majority of the next kilowatt hour of UK/European electricity generation arising from renewables (mainly wind). 2. <u>Waste</u> Using reusables (scenario 1) resulted in less waste (250 kg) compared to using mainly single use (scenario 2; 1222 kg of waste). Scenario 3 had the highest amount of waste (1542 kg) and scenarios 4 and 5 led to 375 and 917 kg of waste, respectively. 3. <u>Acidification</u> No results in this study. 4. <u>Eutrophication</u> These outcomes resulted all in a low impact on eutrophication. Using reusables (scenario 1) resulted in 0.000 kg P equivalents whereas using mainly single use (scenario 2) led to 0.12 kg P equivalents. Scenario 3, 4 and 5 led to 0.12, 0.04 and 0.07 kg P equivalents, respectively. 5. <u>Human Toxicity</u> Using reusables (scenario 1) resulted in 12 kg 1.4-DB equivalents whereas scenario 2 resulted in the highest impact of all scenarios (713 kg 1.4-DB equivalents). Scenario 3, 4 and 5 led to 1.023, 195 and 491 kg 1.4-DB equivalents, respectively. 6. <u>Ecotoxicity</u>		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					The outcome ecotoxicity was divided in three different outcomes: terrestrial, freshwater and marine ecotoxicity. For terrestrial ecotoxicity, using reusables (scenario 1) resulted in 0.011 kg 1.4-DB equivalents whereas scenario 2 resulted in 0.4 kg 1.4-DB equivalents. Scenario 3, 4 and 5 led to 0.405, 0.118 and 0.2 kg 1.4-DB equivalents, respectively. For freshwater ecotoxicity, using reusables (scenario 1) resulted in 0.7 kg 1.4-DB equivalents whereas scenario 2 resulted in 91 kg 1.4-DB equivalents. Scenario 3, 4 and 5 led to 93.4, 3.1 and 88 kg 1.4-DB equivalents, respectively. For marine ecotoxicity, using reusables (scenario 1) resulted in 0.7 kg 1.4-DB equivalents whereas scenario 2 resulted in 94.5 kg 1.4-DB equivalents. Scenario 3, 4 and 5 led to 97.2, 2.8 and 92.3 kg 1.4-DB equivalents, respectively. Moreover, using single-use equipment (scenario 2 and 3) has the highest impact on ecotoxicity. 7. Ozone Depletion No results in this study.		
Namburar (2022)	BMJ Journals Gut Journal information Gut is a leading international journal in gastroenterology and hepatology and has an established reputation for	Type of study: Waste audit (cross-sectional study) Objective: To measure the amount of waste generated during endoscopic procedures	Goal and scope[1]: Quantify waste associated with endoscopic procedures. Functional unit(s)[2]: N/A System boundaries: N/A Included stages: Pre-procedure area,	Namburar (2022) performed an audit of waste generated during endoscopic procedures at a low and high endoscopy volume academic medical center (VA White River Junction, Vermont, USA	1. Climate Change No results in this study. 2. Waste The annual waste produced during endoscopic procedures in the US for the three different scenarios show that the 'all	The study suggests the least amount of waste is produced by using 'all reusable' endoscopes. When only focusing on waste, this should be the best option following the three given scenarios.	Authors conclusion The quantitative assessment shows that endoscopic procedures generate a large amount of waste from disposable instruments. Net waste is

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	publishing first class clinical research of the alimentary tract, the liver, biliary tree and pancreas. Gut is an official journal of the British Society of Gastroenterology and has two companion titles: Frontline Gastroenterology for education and practice and BMJ Open Gastroenterology for sound science clinical research. Critical review: Peer reviewed, not a specific LCA journal.	and to understand the impact on waste of changing from reusable to single use endoscopes in the USA. LCA-method: - Setting and country: Two US academic medical centers in the USA Facility: VA White River Junction, Vermont, USA and Darthmouth Hitchcock Medical Center, New Hampshire, USA Years of data collection: 2020 Surgical discipline(s): Gastro-enterology Funding and conflict of interest: The authors declare no conflict of interest and have not received funding.	examination room and post-procedure area Stated excluded components: Sharp objects in separate containers Inventory database: N/A Allocation: No Normalization & Weighting: Yes, results were normalized to the annual endoscopy procedures in the US. Impacts reported: N/A Contribution analysis: Yes Scenario analysis: No Comparative analysis: Yes Sensitivity analysis: Yes Uncertainty analysis: No Variance analysis: No	and Darthmouth Hitchcock Medical Center, New Hampshire, USA) over a 5-day work period in 2020. Colonoscopies, upper endoscopies and endoscopic retrograde cholangiopancreatography (ERCP) were included. The waste from the pre-procedure area, examination room and post-procedure area was collected and documented as mass and volume. In the high volume hospital the waste from endoscope reprocessing was also obtained. An estimation of the contribution of single-use (compared to reusable) waste was made in the following three scenarios: (1) all reusable endoscopes, (2) colonoscopies and ERCPs were performed with single-use endoscopes (colonoscopes/duodenoscopes) and (3) all single-use endoscopes. The outcome measure was waste. Characterization methods: N/A	reusable' endoscopes (scenario 1) produce the least amount of waste (43,500 metric tons of waste for 18 million endoscopies annually in the US), followed by using single-use colonoscopes/duodenoscopes (scenario 2; 54,375 metric tons of waste) and all single-use endoscopes (scenario 3; 60,900 metric tons of waste). 3. Acidification No results in this study. 4. Eutrophication No results in this study. 5. Human Toxicity No results in this study. 6. Ecotoxicity No results in this study. 7. Ozone Depletion No results in this study.	However there are no further calculations regarding environmental impact. With these calculations, as the authors suggest in the discussion, this would give a better overview of the environmental impact of the procedures, taking the whole life cycle into of the endoscopes (and procedures) into account.	increase by using single-use endoscopes. Limitations study The study suggests to estimate the environmental impact of an endoscopic procedure, however only describes the amount of waste and does not calculate the actual environmental impact.
Rizan (2021)	Surgical Endoscopy Journal information This journal is positioned at the interface between various medical and surgical disciplines, it serves as a focal point for the international surgical	Type of study: LCA Objective: To assess environmental and financial impacts of hybrid and single-use instruments in	Goal and scope[1]: Quantify reduction of the environmental (and financial) impact of hybrid surgical instruments compared to single-use. Functional unit(s)[2]: The number of three types of instruments (clip	Rizan (2021) assessed environmental and financial impacts of hybrid and single-use instruments in laparoscopic cholecystectomy using life cycle assessment. The number of three types of instruments (clip appliers,	1. Climate Change The carbon footprint of the hybrid laparoscopic instruments is lower compared to the single-use instruments. Compared to its single-use equivalent, the hybrid clip applier's carbon footprint was 17% (445 g vs 2559 g CO_2 eq), the scissor 33%	The CO_2 footprint of using hybrid scissors, ports and clip appliers was 76% lower than using single-use equivalents, saving 5.4 kg CO2eq per operation. Overall, the environmental impact of the hybrid instruments are lower	Authors conclusion The CO_2 footprint of using hybrid instruments for laparoscopic cholecystectomy is around a quarter of that for single-use equivalents and the financial costs around half.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	community to exchange information on practice, theory, and research. <u>Critical review:</u> Peer reviewed, not a specific LCA journal	laparoscopic cholecystectomy. <u>LCA-method:</u> Attributional LCA and consequential approach <u>Setting and country:</u> UK <u>Facility</u>: - <u>Years of data collection:</u> 2020 <u>Surgical discipline(s):</u> Gastro-enterology <u>Funding and conflict of interest:</u> Funded by Surgical Innovations Ltd., but played no pared in scientific conduct, analysis or writing of the manuscript. No conflict of interest was stated.	appliers, laparoscopic scissors and ports) typically required to perform one laparoscopic cholecystectomy. <u>System boundaries:</u> Cradle to grave <u>Included stages:</u> Raw material extraction, manufacture, transport, disposal, decontamination for reusable components of hybrid instruments <u>Stated excluded components:</u> Other reusable instruments and consumables used to perform a laparoscopic cholecystectomy <u>Inventory database:</u> Ecoinvent, Industry data <u>Allocation</u>: No <u>Normalization & Weighting</u>: No <u>Impacts reported</u>: Yes <u>Contribution analysis</u>: Yes <u>Scenario analysis</u>: Yes <u>Comparative analysis</u>: Yes <u>Sensitivity analysis</u>: Yes, tests altered electricity source decontamination and changing way of transport <u>Uncertainty analysis</u>: No <u>Variance analysis</u>: No	laparoscopic scissors and ports) typically required to perform one laparoscopic cholecystectomy were included in the analysis (two small diameter ports, two large diameter ports, one laparoscopic scissor and one laparoscopic clip applier). The stages of raw material extraction, manufacture, transport, disposal and decontamination for reusable components of hybrid instruments were included. Data was obtained from manufacturers and databases. <u>Characterization methods:</u> ReCiPe	(378g vs 1139 g CO_2 eq) and the four ports 27% (933 g vs 3495 CO_2 eq). All combined, the carbon footprint of using all hybrid instruments was 24% of that of single-use equivalents (1756 g vs 7194 g CO_2 eq), saving 5.4 kg CO_2 eq. The majority of the carbon footprint of the hybrid instruments was due to single-use components (mean 62%, range 43-79%), followed by decontamination of reusable components (mean 37%, range 21-56%). For the single-use instruments the biggest hotspots were raw material extraction and manufacturing (mean 57%, range 52-61%), followed by onward transportation (mean 29%, range 24-36%) and waste (mean 14%, range 12-16%). The scenario modelling resulted in the following results. When packaging and decontaminating separately, the CO2 footprint of the hybrid clip applier increased 3.7-fold to 1650 g CO2 eq. The scissor increases to 394 g CO2 eq per use (4% increase) and the ports 999 g CO2 eq per use (7% increase). For all hybrid instruments, CO2 footprint was lower than the single-use equivalents when used more than twice. The CO2 footprint of the decontamination process of hybrid instruments increased with 54% when using Australian electricity, which increased the CO2 footprint of the hybrid instruments by 11-30%, but this remained lower than the single-use equivalents (63-77%).	compared to the single-use instruments. This is mainly due to the manufacturing and raw material extraction process.	 <u>Limitations study</u> Data is limited by assumptions (as with all LCAs), however clearly explained.

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					Shipping in place of airfreight (for single-use items) reduced the CO2 footprint by 22-33%. Using three hybrid 5 mm ports and one 10 mm port (635 g CO2 eq/operation) resulted in a 32% reduction compared to the base case (5 mm single-use ports based on a dual pack). 2. <u>Waste</u> No results in this study. 3. <u>Acidification</u> Rizan (2021) reported the results of the three different instruments. The ports had the highest impact in this category (single-use vs. hybrid, 8.91 vs. 2.08 g SO2 eq), followed by the laparoscopic clip applier (single-use vs. hybrid, 8.53 vs. 1.18 g SO2 eq) and the laparoscopic scissors (single-use vs. hybrid, 4.46 vs. 1.44 g SO2 eq). 4. <u>Eutrophication</u> Rizan (2021) reported the results of the three different instruments on eutrophication divided in two categories: freshwater and marine eutrophication. The laparoscopic clip applier had the highest impact in the category “freshwater eutrophication” (single-use vs. hybrid, 0.62 vs. 0.12 g SO2 eq), followed by the ports (single-use vs. hybrid, 0.43 vs. 0.17 g SO2 eq) and the laparoscopic scissors (single-use vs. hybrid, 0.26 vs. 0.17 g SO2 eq). For the category “marine eutrophication” this resulted in the highest impact for the ports		

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					(single-use vs. hybrid, 0.12 vs. 0.07 g SO2 eq), followed by the laparoscopic clip applier (single-use vs. hybrid, 0.09 vs. 0.06 g SO2 eq) and the laparoscopic scissors (single-use vs. hybrid, 0.05 vs. 0.04 g SO2 eq). 5. <u>Human Toxicity</u> Rizan (2021) reported the results of the three different instruments on human toxicity divided in two categories: carcinogenic and non-carcinogenic human toxicity. Overall, the hybrid instruments have a lower environmental impact in this category. The laparoscopic clip applier had the highest impact in the category "carcinogenic human toxicity" (single-use vs. hybrid, 203 vs. 45 g 1.4-DCB eq), followed by the ports (single-use vs. hybrid, 117 vs. 43 g 1.4-DCB eq) and the laparoscopic scissors (single-use vs. hybrid, 91 vs. 65 g 1.4-DCB eq). Although, the hybrid port has a higher impact than the hybrid laparoscopic scissor. For the category "noncarcinogenic human toxicity" the results were as following (from greatest environmental impact to lowest impact): Single-use laparoscopic clip applier (2871 g 1.4-DCB eq), single-use laparoscopic scissor (1386 g 1.4-DCB eq), single-use ports (1013 g 1.4-DCB eq), hybrid laparoscopic scissor (952 g 1.4-DCB eq), hybrid laparoscopic clip applier (576 g 1.4-DCB eq) and hybrid ports (390 g 1.4-DCB eq).		

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					6. Ecotoxicity Rizan (2021) reported the results of the three different instruments on ecotoxicity divided in three categories: “terrestrial”, “freshwater” and “marine” ecotoxicity. Overall, the hybrid instruments have a lower environmental impact in this category, except for the laparoscopic scissors in freshwater and marine ecotoxicity. For terrestrial ecotoxicity, the results were as following (from greatest environmental impact to lowest impact): Single-use laparoscopic clip applier (19,767 g 1.4-DCB eq), single-use laparoscopic scissor (8939 g 1.4-DCB eq), hybrid laparoscopic scissor (5628 g 1.4-DCB eq), single-use ports (4142 g 1.4-DCB eq), hybrid laparoscopic clip applier (3976 g 1.4-DCB eq) and hybrid ports (1171 g 1.4-DCB eq). For freshwater ecotoxicity, the results were as following (from greatest environmental impact to lowest impact): Single-use laparoscopic clip applier (176 g 1.4-DCB eq), hybrid laparoscopic scissor (97 g 1.4-DCB eq), single-use laparoscopic scissor (91 g 1.4-DCB eq), single-use ports (39 g 1.4-DCB eq), hybrid laparoscopic clip applier (36 g 1.4-DCB eq) and hybrid ports (17 g 1.4-DCB eq). For marine ecotoxicity, the results were as following (from greatest environmental impact to lowest impact): Single-use laparoscopic clip applier (230 g 1.4-DCB eq), hybrid laparoscopic scissor (122		

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					g 1.4-DCB eq), single-use laparoscopic scissor (118 g 1.4-DCB eq), single-use ports (54 g 1.4-DCB eq), hybrid laparoscopic clip applier (47 g 1.4-DCB eq) and hybrid ports (23 g 1.4-DCB eq).. 7. <u>Ozone Depletion</u> Rizan (2021) reported the results of the three different instruments on ozone depletion as following (from greatest environmental impact to lowest impact): Single-use ports (0.0013 g CFC11 eq), single-use laparoscopic clip applier (0.0008 g CFC11 eq), single-use laparoscopic scissor (0.0005 g CFC11 eq), hybrid ports (0.0004 g CFC11 eq), hybrid laparoscopic clip applier (0.0002 g CFC11 eq) and hybrid laparoscopic scissor (0.0001 g CFC11 eq).		
Sanchez (2020)	Resources, Conservation & Recycling <u>Journal information</u> Open Access journal with independent editorial board and peer-review process. Contributions from research, which consider sustainable management and conservation of resources are welcomed. The journal emphasizes the transformation processes involved in a transition toward more sustainable production and consumption systems.	<u>Type of study:</u> LCA <u>Objective:</u> To assess the environmental and economic impacts of reusable and disposable blood pressure (BP) cuffs. <u>LCA-method:</u> LCA <u>Setting and country:</u> Outpatient clinic and ambulatory procedure rooms, regular ward and ICU in the US <u>Facility</u>:	<u>Goal and scope[1]:</u> To compare the environmental and economic performance for reusable and disposable BP cuffs, with a focus on cuff design and materials, cleaning agents and processes. This because disposables come into favor despite lack of information about environmental costs. <u>Functional unit(s)[2]:</u> Providing blood pressure readings for a clinic room or ward, under four different health care delivery scenarios. <u>System boundaries:</u>	Sanchez (2020) assessed the environmental and economic impacts of reusable and disposable blood pressure cuffs by using life cycle assessment. Data on materials and manufacturing was gathered through a combination of manufacturer information and physical testing, by weighing component on a scale. Components were identified and matched with information from inventory databases (US-EI LCI database). US EPA database was used for	1. <u>Climate Change</u> Sanchez (2020) reported outcomes using 4 different scenarios: (1) Day office, (2) 1 Day Ambulatory Procedure, (3) 1 Day Regular Ward and (4) 1 Day ICU. Within these scenarios, a division was made between: reusable incineration (1 cleaning/encounter or 1 cleaning/day), reusable landfill (1 cleaning/encounter or 1 cleaning/day), disposable incineration (1 cleaning/encounter or 1 cleaning/day), disposable landfill (1 cleaning/encounter or 1 cleaning/day). The results of these different scenarios are summarized in the supplemental	The overall results show the reusable blood pressure cuff has a lower environmental impact on all impact categories compared to the disposable cuff. The main contributors for the disposable cuff are the production process and the disposal. For the reusable cuff this is mainly due to the production process of the cleaning wipes. However, the environmental impact of the reusable blood pressure cuff remains lower compared to the disposable.	<u>Authors conclusion</u> Environmental considerations will never be paramount in decision making around medical devices or healthcare delivery, however this work shows there are many opportunities to reduce resource use, waste and environmental impact. <u>Limitations study</u> There is data uncertainty associated with some of the modelling parameters (e.g. energy and BP cuff materials).

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
	Emphasis is upon technological, economic, institutional and policy aspects of specific resource management practices, such as conservation, recycling and resource substitution, and of "systems-wide" strategies, such as resource productivity improvement, the restructuring of production and consumption profiles and the transformation of industry. Critical review: Peer reviewed, not a specific LCA journal.	Yale-New Haven Health (YNHH) System in New Haven, Connecticut, USA. Years of data collection: - Surgical discipline(s): - Funding and conflict of interest: The authors declare no conflict of interest. Funding: Dept. of Civil and Environmental Engineering, Northeastern University	Cradle to grave Included stages: Materials and manufacturing, transport, usage, cleaning, disposal Stated excluded components: - Inventory database: US-EI LCI database Allocation: No Normalization & Weighting: Yes Impacts reported: Yes Contribution analysis: Yes Scenario analysis: Yes Comparative analysis: Yes Sensitivity analysis: Yes Uncertainty analysis: No Variance analysis: No	transport packaging information. Multiple cleaning scenarios were developed to represent a diversity of clinical settings in using and cleaning. Only landfill and incineration were included for disposal data and recycling was not taken into account ("as recycling is uncommon (though possible) given the types of plastics an mixed materials employed in the BP cuffs"). Characterization methods: TRACI	material of the study (Sanchez, 2020). For the outcome measure climate change, the overall results show reusable blood pressure cuffs have a lesser environmental impact compared to the disposable variant. The biggest contributor for the disposable is the material and manufacturing process, whereas for the reusable blood pressure cuff the main contributor is the production of the chemical wipes (which are used for cleaning). 2. Waste No results in this study. 3. Acidification The disposable blood pressure cuffs have a higher environmental impact considering acidification compared to the reusable variant. For the disposable cuff, this is especially related to the manufacturing process. For the reusable variant the biggest contributor is the production of the cleaning wipes. 4. Eutrophication The disposable blood pressure cuffs have a higher environmental impact considering eutrophication compared to the reusable variant. For the disposable cuff, this is especially related to the manufacturing process and the disposal of the cuffs. For the reusable variant the biggest contributor is the production of		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					the cleaning wipes and partly the disposal of these wipes. 5. Human Toxicity The disposable blood pressure cuffs have a higher environmental impact considering human toxicity (non-carcinogens and carcinogens) compared to the reusable variant. For the disposable cuff, this is especially related to the manufacturing process and the disposal of the cuffs. For the reusable variant this is mainly due to the production of the cleaning wipes. 6. Ecotoxicity The disposable blood pressure cuffs have a higher environmental impact considering ecotoxicity compared to the reusable variant. For the disposable cuff, this is especially related to the manufacturing process and the disposal of the cuffs. For the reusable variant this is mainly due to the production of the cleaning wipes. 7. Ozone Depletion The disposable blood pressure cuffs have a higher environmental impact considering ozone depletion compared to the reusable variant. This is especially related to the manufacturing process.		
Sherman (2018)	Anesthesia & Analgesia Journal information	Type of study: LCA	Goal and scope[1]: To obtain environmental and financial impacts,	Sherman (2018) assessed the environmental and financial impacts of three	1. Climate Change Sherman (2018) reported outcomes on climate change on	The environmental impact of the reusable stainless steel laryngoscope blades	Authors conclusion The results demonstrate a clear benefit of reusable

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	The "The Global Standard in Anesthesiology," provides practice-oriented, clinical research you need to keep current and provide optimal care to your patients. Brings peer reviewed articles on the latest advances in drugs, preoperative preparation, patient monitoring, pain management, pathophysiology, and many other timely topics. Critical review: Peer reviewed, not a specific LCA journal.	Objective: To assess the environmental and financial impacts of three different types of rigid laryngoscope handle and tongue blade: plastic single-use, metal single-use, and stainless steel reusable (under a range of cleaning options: low-level disinfection, high-level disinfection, sterilization) LCA-method: Attributional LCA Setting and country: US Facility: Yale-New Haven Hospital, New Haven, CT, USA Years of data collection: - Surgical discipline(s): Anesthesiology Funding and conflict of interest: The authors declare no conflict of interest. J.D.S. was supported by an Anesthesia Patient Safety Foundation award. L.A.R. was supported by a Provost's award for undergraduate research at Northeastern University. M.J.E. was supported by departmental start-up funds at Northeastern University.	since it is not clear, to facilitate anaesthesiologists making the best choice considering environmental and economic perspectives. Device efficacy was presumed equivalent. Functional unit(s)[2]: One handle or one blade for a single patient encounter System boundaries: Cradle to grave Included stages: Raw material extraction, production, packaging, transport, use, reuse, disposal Stated excluded components: Machinery and capital equipment; building operations Inventory database: EcoInvent, US-EI Allocation: No Normalization & Weighting: No Impacts reported: Yes Contribution analysis: Yes, only GWP Scenario analysis: Yes, various cleaning options Comparative analysis:: Yes Sensitivity analysis: Yes, assuming a 100% recycling scenario (figure 2) Uncertainty analysis: No Variance analysis: No	different types of rigid laryngoscope handle and tongue blade: plastic single-use, metal single-use, and stainless steel reusable (under a range of cleaning options: low-level disinfection, high-level disinfection, sterilization) by using life cycle assessment and life cycle costing at the Yale-New Haven Hospital, New Haven, CT, USA. To determine the material composition of handles and blades a combination of manufacturer specifications, deconstruction, and density testing were used, and after each material was weighed. Foreground data specific to Yale-New Haven Hospital (YNHH) were collected, including transportation mode and distance; washer and autoclave-related energy, water, and chemical use (based on machine specification and apportioned based on an assumed full-load). Reusable components were assumed to have a lifespan of 4000 uses and require refurbishment every 40 uses, according to rated lifetimes of each component (i.e. 1/4000th of the manufacturing, transportation, and disposal impacts were assigned to 1 use of a	both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection levels (LDL), high-level disinfection levels (HDL) and sterilization). The most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 40% increase of the CO_2 footprint (0.08 kg CO_2 eq per use). Sterilization will lead to a 400% increase (0.23 kg CO_2 eq per use). The single-use handle has a 25 times bigger CO_2 footprint compared to the reusable version (1.41 kg CO_2 eq and 1.60 kg CO_2 eq for the plastic and metal handles, respectively). The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 400% increase (0.22 kg CO_2 eq per use) compared to HDL (0.06 kg CO_2 eq per use). Single-use options for the blades will result in an 6-8 times increase of CO_2 footprint (0.38 kg CO_2 eq and 0.44 kg CO_2 eq for the plastic and metal blades, respectively). 2. Waste No results in this study. 3. Acidification Sherman (2018) reported outcomes on acidification on both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection	and handles is lowest. The greater impact of the disposable variants is due to the material manufacturing and device assembly. The reusables create emissions mainly from reprocessing and are thus reliable on the source of cleaning.	laryngoscope handles and blades over single-use alternatives, with HLD as the least polluting reprocessing method. Limitations study The outcomes are only expressed in percentages (except climate change). It would give a more clear view of the absolute impact if the absolute numbers were stated. The authors state there is an uncertainty test undertaken, however that is not the case.

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
				reusable device). Standard US waste management was assumed: 6% of plastics are recycled, 30%–70% of metals, and remaining solid waste is either landfilled (80%) or incinerated (20%). <u>Characterization methods:</u> TRACI	levels (LDL), high-level disinfection levels (HDL) and sterilization). The most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 70% increase of the CO_2 footprint. Sterilization will lead to a 200% increase. The single-use handle has a 33 times bigger CO_2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 350% increase compared to HDL. Single-use options for the blades will result in an 5-10 times increase of CO_2 footprint. 4. <u>Eutrophication</u> Sherman (2018) reported outcomes on eutrophication on both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection levels (LDL), high-level disinfection levels (HDL) and sterilization). The most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 160% increase of the CO_2 footprint. Sterilization will lead to a 100% increase. The single-use handle has a 65 times bigger CO_2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards.		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					Sterilization will lead to a 150% increase compared to HDL. Single-use options for the blades will result in an 8-15 times increase of CO2 footprint. 5. <u>Human Toxicity</u> Sherman (2018) reported outcomes on human toxicity on both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection levels (LDL), high-level disinfection levels (HDL) and sterilization). This outcome is divided in carcinogenics as well as noncarcinogenics. For the carcinogenics, the most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 200% increase of the CO2 footprint. Sterilization will lead to a 150% increase. The single-use handle has a 45 (plastic) and 250 (steel) times bigger CO2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 150% increase compared to HDL. Single-use options for the blades will result in an 7-160 times increase of CO2 footprint. For the noncarcinogenics, the most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 100% increase of the CO2		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					footprint. Sterilization will lead to a 150% increase. The single-use handle has a 135 (plastic) and 180 (steel) times bigger CO2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 200% increase compared to HDL. Single-use options for the blades will result in an 10-42 times increase of CO2 footprint. 6. <u>Ecotoxicity</u> Sherman (2018) reported outcomes on ecotoxicity on both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection levels (LDL), high-level disinfection levels (HDL) and sterilization). This outcome is divided in carcinogenics as well as noncarcinogenics. For the carcinogenics, the most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 400% increase of the CO2 footprint. Sterilization will lead to a 100% increase. The single-use handle has a 130 (plastic) and 225 (steel) times bigger CO2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 150% increase		

Study	Journal	Study characteristics	Methods	Data collection	Outcomes	Interpretation	Comments
					compared to HDL. Single-use options for the blades will result in an 13-95 times increase of CO2 footprint. 7. Ozone Depletion Sherman (2018) reported outcomes on ozone depletion on both laryngoscope handles and blades (reusable or single-use) as well as on different cleaning scenarios (low-level disinfection levels (LDL), high-level disinfection levels (HDL) and sterilization). This outcome is divided in carcinogenics as well as noncarcinogenics. For the carcinogenics, the most favorable scenario for the handles is the reusable stainless steel handle, treated to HDL. Choosing LDL will result in a 3000% increase of the CO2 footprint. Sterilization will lead to a 200% increase. The single-use handle has a 17 times bigger CO2 footprint compared to the reusable version. The most favorable scenario for the blades is the reusable steel tongue blade treated to (the minimum) HDL standards. Sterilization will lead to a 300% increase compared to HDL. Single-use options for the blades will result in an 3-7 times increase of CO2 footprint.		

[1]Goals and scope: ‘Phase of life cycle assessment in which the aim of the study, and in relation to that, the breadth and depth of the study is established’
[2]Functional unit: Quantified description of the function of a product or process that serves as the reference basis for all calculations regarding impact assessment