A measurement of eco-friendly, sustainable significance

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It is estimated that by 2030, 25% of the world’s population will reside in areas not suitable for human life because of climate change and that the direct healthcare costs related to climate change will increase by $4 billion annually.1,2 The healthcare system is indeed a major contributor to climate change; healthcare accounts for an estimated 8% to 10% of all greenhouse gas emissions in the United States (or 655 million tons of carbon dioxide [CO2] equivalents [CO2 eq] per year) and 25% (or 22.8 million tons of CO2 eq per year) in the United Kingdom.3,4 Carbon footprinting can estimate the overall greenhouse gas emissions originating from a particular sector (eg, healthcare), process (eg, an operation), or product (eg, a surgical instrument).5 Initiatives have been taken at the highest levels internationally to sensitize healthcare providers and third-party payers to the emergency represented by global greenhouse gas emissions, including the 2021 United Nations Climate Change Conference (COP26). Furthermore, in 2022, the White House and the US Department of Health and Human Services published a health sector climate pledge to voluntarily commit to “reduce organizational emissions by 50% by 2030.”6 This pledge has found support from more than 100 entities, including healthcare providers and pharmaceutical companies. Of note, the efforts made by the UK government through the Greener National Health System program have resulted in a 25% decrease in CO2 emissions from the National Health Service since 1990.4,7

Efforts to reduce gas emissions from surgical sources should be proportional to the magnitude of such a multifaceted problem.3,5 As an example, along with energy consumption, the use of anesthetic gases is a major source of greenhouse gas emissions at hospital sites.1 It has been reported that 1 kg of sevoflurane corresponds to 130 kg of emitted CO2 and that 1 kg of desflurane corresponds to 2540 kg of emitted CO2; the difference between these gases is attributable to the longer atmospheric time of desflurane, compared with sevoflurane.8,9 In a study from 2017, using data from 3 high-volume academic centers, MacNeill and colleagues3 estimated that the total operating room–related carbon footprint from Canada, the United States, and the United Kingdom equals 9.7 million tons of CO2 per year, the equivalent of 2 million passenger vehicles.

Cardiothoracic surgery is not exempt from responsibilities regarding CO2 emissions. Conventional cardiac procedures, such as valvular and coronary artery bypass, are associated with average emissions of 124.3 kg of CO2 eq.10 More specifically, 1 coronary artery bypass procedure can produce up to 505.1 kg of CO2 eq.11 Medical devices and consumables were responsible for the majority (80.1% to 86.8%) of CO2 emissions in these 2 studies10,11; most of the calculated carbon footprint was a result of the high volume of plastic waste and single-use sharps and the fact that all waste at the studied institutions (Tufts Medical Center and Lyon University Hospital) was managed as biohazardous waste, requiring energy-intensive disposal.10,11

Switching from single-use devices to reusable devices can bring about a reduction in greenhouse gas emissions.12 Single-use surgical instruments are commonly used in minimally invasive surgery procedures.13,14 Disposable


CENTRAL MESSAGE
The environmental impact of healthcare—in particular, the carbon footprint of surgery practices and processes—should be considered as a new endpoint in clinical trials and clinical practice.
instruments routinely include a metallic component (which is often recyclable) and are made of plastic—that is, a carbon-based polymer combined with different chemicals—and most of these are toxic or even carcinogenic.\(^2\) The production of plastics is responsible for 3.7% of global greenhouse gas emissions, which is projected to increase to 4.5% by 2060.\(^3\) Only 10% of plastics can be recycled; approximately 90% of plastic waste undergoes incineration or is disposed of in landfills.\(^2\) The preference for single-use devices is further complicated by the significant costs of waste disposal, which can amount to 25% of all healthcare expenditures in the United States.\(^15\) For this reason, the suggestion to maximize the use of reusable instrumentation is highly logical.\(^13\)

The recent study from Nordberg and colleagues\(^16\) in *The New England Journal of Medicine* appears in this context. Far from suggesting a definitive solution to the problem of the environmental impact of clinical activities, the authors propose that clinicians and researchers should strive to generate clinically advantageous and eco-friendly and sustainable products or processes by considering the carbon footprint as a measurable end point in randomized clinical trials.\(^16\) Carbon footprint analysis is conducted using life cycle assessment (LCA) as a quantitative and comprehensive method to evaluate the environmental impact of greenhouse gas emissions.\(^16\) In brief, LCA can be used to determine the carbon footprint of a surgical procedure—that is, its impact on global warming. LCA is measured in CO\(_2\) eq emitted in the whole life cycle of a specific product or process involving multiple products.\(^16\) Calculation of the carbon footprint of a surgical procedure is facilitated by the extended follow-up typical of surgical randomized controlled trials or studies of multimodality perioperative regimens.\(^16\)

Demonstration of the robust environmental sustainability of technologies, processes, or products, as advocated by Nordberg and colleagues,\(^16\) can have significant effects. First, the results of LCA could influence policymakers and administrators to draw different conclusions regarding the validity of new technologies, compared with economic analysis, thereby redirecting financial investments. Second, third-party payers could take the carbon footprint into consideration when evaluating reimbursement policies for single interventions, which could discourage the performance of interventions deemed to be hazardous to the environment. Third, the complexity of translational and clinical research would be increased by the ability to assess treatments beyond their clinical impact. With the advent of artificial intelligence to streamline complex computational issues, surgery-related LCA will be easy to perform, and its results will be immediately available in the setting of clinical trials.\(^13,17\) Open-access, free LCA tools, such as openLCA (openlca.org), are currently available.

In addition to their clinical utility, surgical processes often are evaluated in terms of their impact on the financial sustainability of global healthcare.\(^18\) Thoracic surgeons have recently been reminded of the financial toxicity that can be associated with lung cancer surgery.\(^19\) Nordberg and colleagues\(^16\) add a further analytic element that surgeons, immersed in their clinical and translational work, may have to consider as part of the routine design of studies. A 3-tiered system of end points could be included in the assessment of treatment options, with equal analytic weight given to each: the benefit to the patient, the socioeconomic benefit, and the eco-sustainable benefit. From now on, the significance of the link between healthcare—in particular, surgical theaters and processes—and the ever increasingly threatening environmental crisis cannot be neglected.\(^3,5,20\)

### Conflict of Interest Statement
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### References

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