Surgical Oncologists for Sustainability:
A Statement from the SSO Surgical Oncologists for Sustainability Task Force

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Abstract

Global climate change has been shown to have significant health impacts, including increased risk for cancer. Surgery is often a part of multidisciplinary management of cancer, yet the resources used for surgical oncology can contribute to climate change which in turn may further impact the health of patients. In recognizing climate change as a significant issue, many organizations have promoted sustainable practices in healthcare to reduce waste and mitigate the impact of healthcare on the environment. To this end, the Society of Surgical Oncology (SSO) established the Surgical Oncologists for Sustainability Task Force. In this paper, we review the major contributors of cancer surgery to climate change. These include greenhouse gas (GHG) emissions from inhalational anesthetics, waste generation (both solid and liquid) produced during cancer surgery, and energy consumption from operating room (OR) use. We outline potential strategies, both broadly applicable to surgery as well as to specific complex surgical oncology cases, which can promote more sustainability in surgical oncology, in our personal lives, and the lives of our patients. These strategies include recycling or reuse of OR equipment, preference for multi-use instruments, optimization of waste management, building efficiency among team members to minimize OR time and anesthetic gases when possible, leveraging artificial intelligence to streamline cancer diagnosis and treatment plans, and advocacy and unity with other healthcare institutions to recognize and address the importance of sustainability in surgery. We aim to inspire and equip surgical oncologists to advance environmental sustainability.

Introduction

Global climate change has had some impacts on both patients' health and the healthcare system's ability to deliver care. The United States (US) healthcare system generates approximately 10% of the nation's greenhouse gas (GHG) emissions [1, 2], and operating rooms (ORs) generate 30-70% of total clinical waste.[3, 4] Interestingly, if the US healthcare system was a country, it would rank 13th in the world for GHG emissions.[2] Thus, the healthcare system and the industries that support it together contribute to climate change and subsequently its reported impacts on patient disease. There is an interplay between global climate change and cancer, and the resources allocated to the treatment of cancer may amplify factors associated with climate change. With a large proportion of these issues and their impact emanating from the OR, surgeons may play an important and unique role in improving the sustainability of healthcare systems. Surgical oncologists can have a direct impact on sustainability in surgery, and in this paper we outline areas where all surgeons who treat cancer may promote sustainable cancer surgery.

Increasing evidence suggests that climate change is correlated with global cancer incidence.[5] Climate change-related extremes can increase patient exposure to carcinogens, which promote the incidence of different common cancers, like lung cancer.[6] Climate change also increases patient exposure to ultraviolet (UV) radiation, increasing the risk of skin cancer.[7] Climate change may also impact the timely delivery of cancer care.[8] Nogueira *et al* found that having a hurricane disaster declared during radiotherapy for patients with locally advanced non-small cell lung cancer was associated with worse overall survival and that this relationship was directly associated with the duration of the disaster.[9]

The consequences of climate change may disparately impact underserved and minority populations. Exposure to environmental contaminants has been historically and systematically concentrated in communities of color and low-income inhabitants.[10] In addition, these communities are less likely to have climate-resilient infrastructure, putting them at increased risk

for displacement during natural disasters, which further limits access to healthcare.[10] Similarly, military and veteran populations are at increased risk of service-related exposure to contaminants and the associated consequences, including cancer.[11, 12]

When considering contributions of surgical oncology to climate change, we can consider all phases of perioperative care. Preoperative considerations include packaging and supply chain as well as patient transportation and diagnostic testing,[13] which may have a disproportionate impact within surgical oncology where patients in the US often travel far distances to highly specialized tertiary care centers.[8] Cancer patients often have requirements for preoperative and surveillance imaging. One study found that a CT scan generated 10.2-15.8 kg of CO_2 emission and an MRI generated 33.4 kg of CO_2 per patient.[13] Intraprocedural contributions include temperature control and air circulation, anesthetic gases, disposable drapes and single use devices,[14] and hand disinfection.[15]

The application of robotic surgery to complex surgical oncology cases has been associated with a higher carbon footprint than open and laparoscopic approaches.[16] Additionally, research and clinical trials independently contribute to the healthcare carbon footprint.[17, 18] Specific procedures within surgical oncology, such as hyperthermic intraperitoneal chemotherapy (HIPEC) and electrostatic pressurized intraperitoneal aerosol chemotherapy (ePIPAC), may contaminate OR surfaces with toxic chemicals.[19, 20] Cytotoxic drugs administered during these treatments are poorly biodegradable and resistant to standard treatment procedures,[21] which may have harmful environmental effects.[22] As technology and innovation continue to emerge in surgical oncology, it is important to develop and implement treatment advances in a sustainable manner.

Initiatives on both the national and international levels have been established to address climate change. For example, the Department of Health and Human Services (DHHS) has announced a mandate to decrease healthcare GHG emissions by 50% by 2030 and has published a pledge for healthcare organizations to commit to this goal.[23] Similarly, the Joint

Commission has identified environmental sustainability as one of its three main priorities.[24] In this context, the SSO Sustainability Task Force has been established to help guide our field towards carbon neutrality, inform best practices for sustainable surgery, and interface with clinicians, administration, and surgeon-leaders.[1, 25, 26]

Greenhouse gas (GHG) emissions

GHG emissions play a major role in climate change by trapping solar radiation and raising the Earth's temperature.[27] Higher temperatures cause secondary effects to the polar ice caps, raising the sea level and leading to more extreme weather conditions.[28, 29] Global climate change may potentially cause an additional 250,000 deaths per year according to the WHO.[30] Climate change can also be a financial burden, and by 2030 may increase government spending by 2 to 4 billion dollars to address and mitigate the health effects of climate change.[30]

The healthcare industry accounts for approximately 10% of the total GHG emissions in the US.[31] The Greenhouse Gas Protocol divides the sources of GHG emissions into three "scopes" based on how they contribute to climate change.[32] Scope 1 is the direct release of GHG. Scope 2 is indirect and includes the consumption of energy that powers facilities, such as hospitals. Scope 3 is also indirect and encompasses the energy consumption for the supply chain and waste elimination involved in delivering healthcare.[32]

The OR is a major contributor to Scope 1 GHG emissions through the use of inhaled anesthetic gases and accounts for a third or more of the total waste produced.[3] The commonly used inhaled anesthetics are desflurane, isoflurane, nitrous oxide (N_2O), and sevoflurane. They each have different chemical profiles and impact on the environment. Global Warming Potential (GWP) is a measure used to quantify and compare the effects of various gases.[33] GWP is calculated based on the chemical half-life and its ability to absorb radiation. For example, sevoflurane has a GWP of 130 and an atmospheric life of 1.1 year, which means that 1 kg of sevoflurane retains as much energy as 130 kg of CO_2 over a period of 100 years (GWP100).[34]

Desflurane has the highest GWP100 at 2540 and a total lifetime of 14 years.[34] In comparing desflurane with sevoflurane, desflurane contributes 26 times more to global warming. The effect of inhaled anesthetic drugs is further apparent when they are contrasted with intravenous (IV) drugs (like propofol), which have a lower carbon footprint by 4 orders of magnitude.[35] The American Society of Anesthesiologists (ASA) has directed clinicians to be cognizant of these effects and has urged reduction of desflurane and N_2O by 50%.[36, 37] Inhaled anesthetics that are exhaled by patients in the recovery room and the small amount that escapes from the anesthesia containment unit are called waste anesthetic gases (WAGs).[38] Lastly, there are recommended policies from many countries on the threshold of exposure to gases for employees.[39] The US National Institute for Occupational Safety and Health (NIOSH) has recommended a threshold of 25 ppm for N_2O and 2 ppm for other inhaled gases.[40] Scavenging systems can help to remove WAGs, but there is variability in the functioning and access to WAGs.[41, 42] Table 1 summarizes the GHG characteristics of common anesthetic gases.

Table 1. Characteristics of anesthetic gases

Anesthetic Gas	GWP	ATM Life	WAG threshold	Relative impact to climate change
Desflurane	2540	14	2	↑↑↑↑
Enflurane	0.02-0.14	4-21.4	75	↑
Halothane	50	1	2	↑
Isoflurane	510	3.2	2	↑↑↑
Sevoflurane	130	1.1	2	↑↑
Nitrous oxide	298	114	25	↑↑↑

GWP - Global Warming Potential
ATM Life - atmospheric lifetime (years)
WAG - waste anesthetic gases (ppm)

Impact of surgical oncology care on climate warming

Innovative cancer-directed technologies may help contribute to sustainable surgery. Surgical oncologists and our colleagues in cancer-related specialties are poised to develop novel treatment techniques that may minimize time spent in the OR and subsequently reduce the use and release of anesthetic gases, while still providing durable responses for cancer patients. Examples of new technologies can be found in multiple disease groups.

In the management of breast cancer, cryoablation may soon be approved for early stage (T1) tumors based on results of the ICE3 trial.[43] Cryoablation is performed as an office procedure under local anesthesia and does not require anesthetic gases or other resources inherent to the OR. For axillary staging with pre-operative lymphoscintigraphy, many practices will perform tracer injection prior to the OR. As compared to intra-operative dye injection, pre-operative injection can save time spent in the OR and anesthetic use. While the time and anesthetic gas saved with each individual breast case may be small (e.g., 5-10 minutes), the benefits of reduction may increase immensely over the hundreds of thousands of breast cancer cases that occur annually worldwide. In the management of cutaneous oncology, choosing to perform wide local excisions in the clinic or procedure room whenever possible can also minimize OR time and anesthetic use.

For deeper space malignancies, emerging ablative technologies are being investigated as potential alternative therapies. Techniques such as high-intensity focused ultrasound (HIFU) or pulsed electrical field therapy (PEF) have been applied to a variety of deep space malignancies.[44, 45] With more research, treatments outside of the OR may have an increasing role in cancer care. Overall, reducing surgical time in the OR may become a practical, potentially high-impact strategy for improving environmental sustainability in healthcare. Reducing volatile anesthetic emissions and OR energy consumption would contribute to a lower carbon footprint while maintaining high-quality cancer care.

Surgeons can also directly mitigate the climate impact of the OR by making strategic choices to reduce surgical time. For example, a well-trained and coordinated team, specifically a dedicated and experienced OR team (often required for more complex surgical oncology cases), can increase OR efficiency.[46] In fact, familiarity among the surgical team, particularly between the surgeon and the scrub tech, not only improves patient outcomes but also reduces the duration of cases.[46] Among all cancer subspecialties, deliberate supervision of residents for specific aspects of an operation is important because resident participation in the surgical team has been

shown to increase operative time.[46] Efforts to improve efficiency and sustainability in cancer surgery should be balanced with resident and trainee education. Standardization of intraoperative procedural tasks among all team members has been shown to reduce OR time, which can further contribute to lower GHG emissions.[47]

There are numerous examples of deliberate choices that may reduce costs and mitigate the effects of surgery on GHG emission. Surgical oncologists may consider implementing the win-win/no-regret framework in making wise choices related to cancer surgery.[48] These are actions that are timely, cost-effective, and do not involve detrimental trade-offs with other policies or objectives, which may lead to durable actions in promoting sustainable surgery.

Peri-operative interventions to improve sustainability

Change may require individual surgeons to promote environmental sustainability, starting in our own ORs. There are several interventions that surgeons and hospitals may undertake to reduce the impact on the environment and improve sustainability.

Hospital waste management from the OR is an area of opportunity for pursuing more sustainable practices. Surgical waste is often unsorted and emptied into hazardous waste bins, which require incineration prior to being sent to landfills. Plastics represent a significant component of OR waste, with the incineration of plastics being especially problematic. Initiatives to divert recyclable plastics from the OR would decrease carbon emissions by averting the environmental costs of incineration.[49] Segregation of plastic waste before incineration may also reduce ozone depletion and the formation of fine particulate matter, which contribute to climate change. Recycling of plastic materials is limited due to concerns of propagating patient infection from recycling and reuse. However, recycling could reduce GHG emissions by 30% or more. Recycling of plastics would also reduce the need for the generation of new plastics.

ORs produce significant amounts of fluid waste, with up to 12 liters produced from a single procedure and 2 tons of fluid waste per month.[50] Traditional waste collection systems require

multiple canisters and tubing systems, further contributing to plastic waste. The use of the Neptune fluid collection system may not only reduce the total weight of device-related waste products by 98.5%, but also reduce the burden on OR staff and their time spent disposing of the waste.[51] Altogether, these actions could improve productivity. The chemotherapy used in HIPEC procedures is unable to be collected in the Neptune canisters. Instead, this chemotherapy is separated, placed in sealed containers, and then incinerated. However, the Neptune may be used during the case before the chemotherapy is administered to the patient. This approach may successfully decrease some fluid waste components during HIPEC.

The use of energy devices, such as the Ligasure and Enseal, has become standard in many oncologic cases. These devices have been proven to be safe, increase operative success, and reduce operative time, which collectively improves patient outcomes.[52-54] However, these devices are expensive and are currently manufactured as single use items, further contributing to plastic waste and repurchasing costs. Some hospitals have been successfully reprocessing single use devices (SUDs) for many years.[55] The US Government Accountability Office (GAO) stated in 2008 that existing data did not indicate that reprocessing SUDs presented an elevated health risk and that the adverse event rate was similar to those reported for new devices.[56] Reprocessing allows for a 50% reduction in cost compared to purchasing new equipment, which also reduces waste.[55] One reprocessing center reported $1 billion in savings and 24 million pounds of waste reduction for the 1,700 medical facilities that it served over the last 20 years.[55] Importantly, the function of these instruments does not appear to be compromised by reprocessing. Another study evaluated vessel sealing devices for re-sterilization, finding that these devices can be successfully cleaned, re-sterilized, and continue to function properly for a minimum of 10 cycles.[57] Repurposed devices are less likely to be labeled as defective by a surgical team during surgical simulations.[58] A Canadian survey demonstrated that 28% of 398 hospitals reuse devices labeled as single use.[50] In 2008, Kaiser Permanente Health System elected to participate in a processing service which reduced waste by 208,200 pounds and saved

$5.7 million in repurchasing costs.[50] The ability to clean and reuse items labeled as single use can decrease waste and cost without apparent compromise to patient safety.

In addition to reprocessing devices, surgeons may consider multi-use devices rather than single-use devices. Examples include multi-use staplers, reusable clip appliers, saw blades, and basins. Each multi-use device could reduce the volume of waste created and reduce plastic packaging.[59] In a study of bariatric cases, multi-use staplers led to 40% less waste, up to 60% less packaging, a 90% reduction in resource consumption, and significant reductions in GHG emissions related to reduced use of lithium-ion batteries.[59]

Another initiative to decarbonize perioperative services is to transition to reusable perioperative gowns and drapes. Reusable textiles were historically the norm for ORs; however, about 80% of hospitals in the US use disposable surgical gowns today.[60] This difference in market share between reusable and disposable perioperative textiles is somewhat counterintuitive, considering that reusable gowns provide more protection against bodily fluids,[61] require 64% less energy and generate 66% less carbon emissions,[60] and have been shown to have equal or better user experience and wearing comfortability compared to disposable gowns.[62] In fact, institutions that have transitioned to reusable perioperative textiles in their ORs have demonstrated excellent uptake of the reusable surgical gowns, along with significant reductions in waste and cost.[63]

Preference cards are used to determine which instruments and supplies are needed for any given case and surgeon, and these represent another opportunity to promote sustainability. Preference cards may contain instruments and supplies that a surgeon currently does not use and lack important items that are routinely used.[64] Having unnecessary instruments, surgical supplies, and suture can lead to increased waste, costs, and delays in case starts and progression.[64] Preference cards can be reviewed by individual surgeons and the service line to ensure that all items listed are needed for a given operation.[50] If an item is not routinely used during an operation, it can be placed on a secondary list so that the OR staff will know to have it

available in the room but not yet open it. Once on the sterile field, an unused instrument will either be placed into the waste bin or will have to be cleaned and reprocessed as part of standard protocol. In a study by Scheinker *et al*, the authors formulated an algorithm to optimize surgeon preference cards to impact cost savings in the use of surgical supplies.[64] Their team analyzed 23,722 procedures and edited 309 preference cards, with a decrease of 8.4% in the average direct cost of supplies per case.[64] Adjusting surgeon preference cards may also decrease the OR time needed to count unnecessary instruments and supplies, anesthetic gas use, and materials in sterilization and processing.[65] Embick *et al* conducted a study examining the use of surgeon education and universal preference card utilization at two institutions and observed a decrease in OR disposable supply costs.[66] Optimization of surgeon preference cards could promote streamlined instruments and supplies in the OR, while decreasing sterilization and waste disposal costs.

Closely aligned with preference card optimization is review of OR packs or bundles. Bundled items may save time and packaging, assuming that all the items are used. In a study by Bravo *et al*, the authors evaluated 85 hand surgery cases to assess the number of sterile instruments that were opened for each case but not used during the case. The authors calculated 981 unused items during the study period, with an average of 22.6% of the items in custom packs being unused.[67] Bundles can routinely be reviewed for items that are not regularly used. Attention to individual surgeon preferences by institutions and by industry when preparing bundles can have a significant impact on waste reduction in the OR.[50] An option to promote individualization of the case bundles could occur by allowing an institution's central supply group to assemble the bundles. Attention should also be given to greener packaging. For example, the commonly used blue wrap that encloses trays of sterile surgical instruments is made of a type of plastic that is not biodegradable. However, it can be recycled by other companies, thus removing it from hospital waste.[67] Since plastic packaging is a significant contributor to OR waste,

reusable metal cases can be used for instrument packaging, which would also offer improved protection during transport and storage.[50]

Lastly, surgeons can advocate for OR facilities' management to plan for HVAC (heating, ventilation, and air conditioning) systems to operate based on occupancy and reduce airflow in unused ORs overnight and on weekends. ORs are estimated to consume 3-6 times more energy per square meter than other hospital space, and the largest contribution to this energy use is the HVAC system, which consumes 90-99% of overall OR energy use.[3]

Sustainability in our personal lives

Outside of the hospital, there are many ways to practice sustainability and impact the environment. As surgical oncologists, we commonly counsel our patients on modifiable risk factors like smoking and vaping cessation, wearing sunscreen, and keeping current with age-appropriate screenings. It may be a natural segue for surgical oncologists and other physicians to inform our patients about how sustainable living can also decrease cancer risk.

Diet is a common topic of conversation during clinic visits. Physicians focus on how patients' diets and wellness can change their personal outcomes, but physicians and surgeons can also emphasize the advantages of an environmentally sustainable diet. Up to 30% of human-made GHGs comes from the production, distribution, and destruction of food.[68] Obtaining protein from beef creates 190 times more GHGs than attaining that same amount of protein from nuts. By shifting to plant-based diets, GHGs from food could be reduced by up to 70%.[69] Even shifting to lower-impact meats (e.g., chicken or fish) may also reduce emissions.

Transportation is a significant source of GHGs and may be responsible for up to 70% of global gasoline gallon equivalents (GGEs), [70, 71] which approximates the amount of the equivalent energy content within 1 gallon of gasoline.[72, 73] Approximately 75% of transport CO_2 emissions come from road vehicles.[74] Public transport, carpooling, and biking are ways that caregivers and our patients can minimize the carbon footprint related to transportation. While

electric vehicles have their own environmental issues, over their lifetime they produce fewer emissions compared to conventional gas powered vehicles.[75] Since flying creates the most emissions per kilometer travelled,[74] physicians may also advocate to organize scientific meetings and conferences in ways to minimize long-distance travel. Options for virtual attendance, for example, could be offered where appropriate.

Personal electronic ownership has increased over the last decade, and has a number of negative effects on the environment, potentially harming human health and the health of other living beings. Over 50 million tons of electronic waste per year are produced mining the essential metals for batteries, which leads to a ten-fold increase in kg of GGE per kg of metal extracted.[76] Landfill waste related to discarded electronics significantly pollutes the environment and ecosystems. Making homes more energy efficient and choosing a clean electricity provider are other ways that physicians may personally impact the environment. A personal choice to minimize one's consumption can collectively lead to a positive impact on the environment and reflect our efforts in the workplace.

Many societies like SSO have acknowledged that healthcare plays a significant role in the climate crisis. Surgical oncologists have an opportunity to advocate through the SSO to make environmental sustainability a priority. Similar efforts in other medical and surgical societies would be anticipated to have an even more significant impact on sustainability.

Discussion and future directions

SSO endorsement and commitment

In 2024, the SSO Board of Directors endorsed the formation of a new taskforce for engaging the SSO in initiatives to address climate change. The taskforce, named the Surgical Oncologists for Sustainability (SOS) seeks to inspire and equip surgical oncologists to advance environmental sustainability in their work and daily lives. Focusing on education, action, and

advocacy, the task force is actively working with on climate initiatives that may positively affect cancer surgeons and the patients we serve.

Table 2. SSO Surgical Oncologists for Sustainability Taskforce Mission Statement
• **Mission:** Inspire and equip surgical oncologists to advance environmental sustainability in their work and daily lives. • **Vision:** A future where health care providers are an effective force for combatting climate change for our patients and our planet. • **Values:** ⇒ We reduce waste in our personal lives and in our workplace. ⇒ We are creative and collaborative problem solvers, building on the work of others. ⇒ We advocate and educate to promote sustainable practices. ⇒ We view climate change activism as an urgent moral and ethical imperative.

Recycling

While recycling should be considered as a last resort in sustainability, single-use plastics are an unavoidable reality of the medical industry. They are cheap and easy to manufacture and transport, owing to their lightweight and flexible properties, and plastic helps ensure sterility of medical products and drugs. Identifying a sustainable solution to dispose of non-biohazard plastics is an ongoing challenge. The reality is that only around 5% of all plastic waste is recycled.[77] Furthermore, the primary method of plastics recycling currently is via pyrolysis, which incinerates plastics to a high temperature, a process that may be even more detrimental and toxic to the environment compared to burying plastics in landfill.[78]

We list recycling as a priority, while also recognizing that there are limitations to recycling. We can advocate for more transparency on how plastics are recycled and for the development of programs and economic incentives to make plastics more easily recyclable. Currently, only #1 and #2 plastics are recycled consistently in the US, although still at low rates. Some medical plastics are made of #2 plastics (high density polyethylene), including IV bag overwraps and saline irrigation bottles, which may be an easy first target for hospitals to consider when expanding recycling initiatives. Other plastics, such as #5 plastics (polypropylene, which is used to make blue wrap) and #3 plastics (polyvinyl chloride, used in IV bags) are not as readily recycled. Decreasing usage of these plastics when making new products may be a reasonable approach.

Cancer surveillance

While it is recognized that early detection of cancer recurrence can improve survival and prognosis in certain cases, the optimal time interval for ordering repeat scans and labs still varies in guidelines. For example, NCCN guidelines for surveillance of resected stages II and III colon cancer recommend CT chest, abdomen, and pelvis every 6-12 months for a total of 5 years and CEA every 3-6 months.[79] Some studies have proposed less frequent surveillance without detriment to patient outcomes.[80], [81] While these studies did not comment on the environmental impact from different surveillance strategies, the risk for environmental harm includes the energy consumption used by the CT scanner, contrast agents released into wastewater, and waste generation from needles and tubing. In fact, it is estimated that a single abdominal CT scan results in approximately 10 kg of CO_2 emissions, or the equivalent of driving a car for 76 km.[82, 83] Considering the number of patients diagnosed with colorectal cancer yearly in the US alone, it is important to continue to investigate optimal surveillance strategies for our patients that provide the best outcomes and may also promote sustainable practices that simultaneously benefit the environment.

Leveraging artificial intelligence

Artificial intelligence (AI) systems have been studied to improve and streamline delivery of healthcare in ways that would also have positive environmental impacts downstream. For instance, a group from NYU trained a deep learning (DL) model with 298 3-T MRI knee examinations to reconstruct knee MRIs prospectively with an accelerated protocol.[84] Mean scan times for DL imaging was reduced to 5 minutes 33 seconds from 9 minutes 56 seconds for conventional imaging, and the overall quality of DL-reconstructed images were judged to be significantly better by six musculoskeletal radiologists.[84] Using AI in a manner that could improve efficiency of MRIs and improve diagnostic capabilities should theoretically decrease the environmental impact of these studies. Other AI applications in oncology that have been studied

include improved classification of skin cancer images,[85-87] the development of a software system (called Paige Prostate) for diagnosing prostate cancer from core biopsy specimens,[88] and training an AI model to predict patient-specific cancer responses and resistance to specific drugs.[89] One could imagine that improved accuracy in both the diagnosis and treatment of cancer may lead to fewer studies and tests ordered, streamline treatment, and decrease energy consumption and waste. However, it is also important to recognize that developing and using AI currently uses an enormous amount of energy. Training an AI model can use up to the same amount of energy consumed by 130 homes in the US yearly[90]. As we move forward with using AI, it is important to consider the environmental impacts in addition to the clinical and economic impacts of AI.

Unity with other organizations

A multinational survey study was published in 2021 that queried physicians and nurses from different medical associations and organizations on their viewpoints on climate change.[91] More than half of all participants reported already seeing impacts of climate change on their communities' health, including reduced air quality, physical and mental harm from fires or storms, and effects on mental health in general. The majority of participants (86%) agreed that health professionals have a responsibility to raise public awareness of the health effects of climate change, and most felt that professional societies should align with climate-forward policies.

The World Health Organization (WHO) established a Working Group on Health in Climate Change (HIC) in an effort to support the WHO Global Strategy on Health, Environment and Climate Change.[30, 92] The Working Group emphasized the need to use the lessons learned from the COVID-19 pandemic to prepare a response to the environmental global crisis and its effects on public health through specific actions. These included the need for cost-effective solutions and an understanding of the finances involved. Goals included a "net zero" health service delivery by 2050 and active participation of the health care community (including patients,

health care professionals, and industry) in the planning and implementation process.[93, 94] For surgical oncologists and other surgeons, this would mean assessing both the vulnerabilities and capabilities of our individual health care settings (i.e., OR, inpatient wards, outpatient clinics), quantifying the cost of action and inaction, identifying best practices, and promoting a culture where the effect on the climate is considered in all parts of the surgical process and by all stakeholders (i.e., patients, nurses, surgeons, administrators). A shared mental model among healthcare providers is essential to accomplish these goals.

To this end, many societies such as the American Society of Clinical Oncology (ASCO), the American Society for Radiation Oncology (ASTRO), and the American College of Surgeons (ACS) have made statements regarding the responsibility of the healthcare sector towards mitigating climate change. Next steps moving forward may include multidisciplinary guidelines for the best sustainable practices in cancer care.[95] Research studies may also begin to consider the environmental impact and life-cycle assessments of new technologies and treatments alongside clinical outcomes. Involvement of the SSO is of paramount importance to improve sustainability outcomes in cancer care.

It is critical to showcase the implementation of sustainable interventions in hospitals and ORs. Hospitals can advertise having an environmentally sustainable surgical system, thus emphasizing their sensitivity for social justice and responsibility. Furthermore, environmental sustainability measures would fulfill Joint Commission criteria as part of the Sustainable Health Certification Program, which was implemented in January 2024.[96] This goes along with the concept of the anchor institution, which means that these hospitals, healthcare facilities, surgical oncology centers or departments, all represent large organizations with deep roots in the community and an active bidirectional relationship with the patients and the community as a whole.[97, 98] As such, efforts to increase sustainability may gain momentum in these anchor institutions, while at the same time make them leaders in the field of sustainability. The SSO and its members can recognize such institutions, and together with other national and international

surgical organizations, help lead the change to more sustainability in surgical oncology and in surgery as a whole.

SSO commitment

The SSO Surgical Oncologists for Sustainability (SOS) Task Force has launched several first initiatives to inform and equip surgical oncologists and the surgical taskforce more broadly. Through these activities, in collaboration with sustainability partners, we aim to drive actions to create a more sustainable future for surgeons, patients, and our planet. Future activities will be focused on measuring our collective impact and inspiring stakeholders across all areas of healthcare to engage in sustainability measures in their workplaces and their personal lives.

Table 3. SSO Surgical Oncologists for Sustainability Taskforce Current Initiatives

Initiative		**Goal**
Sustainability Nuggets	Monthly communication provided to the SSO membership, focused around one idea that relates to surgeons, cancer and climate sustainability	Educate
Greening the Meeting	Build a suite of initiatives and activities around the annual meeting to bring awareness to how SSO members can reduce their carbon footprint both at work and in their daily lives	Create awareness
OR Instrument Optimization	Create a resource of OR preference card templates which have been designed to reduce perioperative waste	Reduce
Equipment Repurposing	Identify opportunities to partner with regional and global partners to collect and repurpose OR supplies and equipment	Reuse, Recycle
SSO Web page, social media, electronic communication strategy	Establish a web and social media presence that will be a hub to share ideas, best practices, and examples of successful implementation of sustainability measures. Designed to target the SSO community as well as other stakeholders across healthcare	Build community and create advocacy

References

1. Dzau VJ, Levine R, Barrett G, et al. Decarbonizing the U.S. Health Sector - A Call to Action. N Engl J Med. 2021; 385: 2117-2119.
2. Eckelman MJ, Sherman J. Environmental Impacts of the U.S. Health Care System and Effects on Public Health. PLoS One. 2016; 11: e0157014.
3. MacNeill AJ, Lillywhite R, Brown CJ. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. Lancet Planet Health. 2017; 1: e381-e388.
4. Babu MA, Dalenberg AK, Goodsell G, et al. Greening the Operating Room: Results of a Scalable Initiative to Reduce Waste and Recover Supply Costs. Neurosurgery. 2019; 85: 432-437.
5. Schiller JH. Climate change: why oncologists need to get involved. BJC Rep. 2024; 2: 20.
6. Hill W, Lim EL, Weeden CE, et al. Lung adenocarcinoma promotion by air pollutants. Nature. 2023; 616: 159-167.
7. Parker ER. The influence of climate change on skin cancer incidence - A review of the evidence. Int J Womens Dermatol. 2021; 7: 17-27.
8. Bernicker E, Averbuch SD, Edge S, et al. Climate Change and Cancer Care: A Policy Statement From ASCO. JCO Oncol Pract. 2024; 20: 178-186.
9. Nogueira LM, Sahar L, Efstathiou JA, et al. Association Between Declared Hurricane Disasters and Survival of Patients With Lung Cancer Undergoing Radiation Treatment. JAMA. 2019; 322: 269-271.
10. Ashad-Bishop KC, Cruz M, Bailey ZD, et al. Intersectional disparities in climate vulnerability and cancer risk. Cancer. 2023; 129: 2122-2127.
11. Kronstedt S, Cathey J, Chiu CB, et al. Exposures and Bladder Cancer Risk Among Military Veterans: A Systematic Review and Meta-analysis. Urology. 2024; 194: 270-277.
12. Joshi M, Joshi A, Bartter T. The impact of climate change on respiratory health: current understanding and knowledge gaps. Curr Opin Pulm Med. 2025; 31: 79-88.
13. Cunha MF, Pellino G. Environmental effects of surgical procedures and strategies for sustainable surgery. Nat Rev Gastroenterol Hepatol. 2023; 20: 399-410.
14. Rizan C, Bhutta MF. Environmental impact and life cycle financial cost of hybrid (reusable/single-use) instruments versus single-use equivalents in laparoscopic cholecystectomy. Surg Endosc. 2022; 36: 4067-4078.
15. Jehle K, Jarrett N, Matthews S. Clean and green: saving water in the operating theatre. Ann R Coll Surg Engl. 2008; 90: 22-24.
16. Woods DL, McAndrew T, Nevadunsky, N et al. Carbon footprint of robotically-assisted laparoscopy, laparoscopy and laparotomy: a comparison. Int J Med Robot. 2015; 11: 406-412.
17. Adshead F, Al-Shahi Salman R, Aumonier S, et al. A strategy to reduce the carbon footprint of clinical trials. Lancet. 2021; 398: 281-282.
18. Lyle K, Dent L, Bailey S, et al. Carbon cost of pragmatic randomised controlled trials: retrospective analysis of sample of trials. BMJ. 2009; 339: b4187.
19. Rodier S, Saint-Lorant G, Guilloit JM, et al. Is hyperthermic intraperitoneal chemotherapy (HIPEC) safe for healthcare workers? Surg Oncol. 2017; 26: 242-251.
20. Roussin F, Taibi A, Canal-Raffin M, et al. Assessment of workplace environmental contamination and occupational exposure to cisplatin and doxorubicin aerosols during electrostatic pressurized intraperitoneal aerosol chemotherapy. Eur J Surg Oncol. 2021; 47: 2939-2947.
21. Janik-Karpinska E, Brancaleoni R, Niemcewicz M, et al. Healthcare Waste-A Serious Problem for Global Health. Healthcare (Basel). 2023; 11.

22. Mišík M, Filipic M, Nersesyan A, et al. Environmental risk assessment of widely used anticancer drugs (5-fluorouracil, cisplatin, etoposide, imatinib mesylate). Water Res. 2019; 164: 114953.
23. US Department of Health and Human Services. 2025. https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/index.html. Access 18 February 2025.
24. NEJM Catalyst. 2025. https://catalyst.nejm.org/doi/full/10.1056/CAT.22.0341. Accessed 18 February 2025.
25. Pietrabissa A, Sylla P. Green surgery: time to make a choice. Surg Endosc. 2023; 37: 6609-6610.
26. Vandenberg J JS, Gabriel E, and Sylla P. Sustainable Surgery. In: The SAGES Manual of Strategy and Leadership, 1st ed. Springer, 2024.
27. NASA. 2025. https://climate.nasa.gov/causes/ CFCCVSotPaoNAo. Accessed 18 February 2025.
28. World Meteorological Organization. 2025. https://wmo.int/news/media-centre/past-eight-years-confirmed-be-eight-warmest-record. Accessed 18 February 2025.
29. National Centers for Environmental Information. 2021. https://www.ncei.noaa.gov/new/ocean-heat-content-rises. Accessed 18 February 2025.
30. World Health Organization. 2021. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health. Accessed 18 February 2025.
31. Commonwealth Fund. 2022. https://www.commonwealthfund.org/publications/explainer/2022/apr/how-us-health-care-systems-contributes-climate-change. Accessed 18 February 2025.
32. Ranganathan J CL, Pankaj B, et al. The greenhouse gas protocol: a corporate accounting and reporting standard. WBCSD. 2004. 1–116.
33. Raga Mexico G, Ramanathan V, Ramaswamy V, et al. The Physical Science Basis. Contribution of Working Group I. 2007. https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf. Accessed 18 February 2025.
34. Sulbaek Andersen MP, Nielsen OJ, Sherman JD. Assessing the potential climate impact of anaesthetic gases. Lancet Planet Health. 2023; 7: e622-e629.
35. Sherman J, Le C, Lamers V, et al. Life cycle greenhouse gas emissions of anesthetic drugs. Anesth Analg. 2012; 114: 1086-1090.
36. Devlin-Hegedus JA, McGain F, Harris RD, et al. Action guidance for addressing pollution from inhalational anaesthetics. Anaesthesia. 2022; 77: 1023-1029.
37. American Society of Anesthesiologists. 2025. https://www.asahq.org/about-asa/governance-and-committees/asa-committees/committee-on-equipment-and-facilities/environmental-sustainability/inhaled-anesthetic-2020-challenge. Accessed 18 February 2025.
38. Centers for Disease Control. 2025. https://www.cdc.gov/niosh/docs/2007-151/pdfs/2007-151.pdf?id=10.26616/NIOSHPUB2007151 WAG-OHiHaoFAo. Accessed 18 February 2025.
39. Irwin MG, Trinh T, Yao CL. Occupational exposure to anaesthetic gases: a role for TIVA. Expert Opin Drug Saf. 2009; 8: 473-483.
40. Centers for Disease Control. 2025. https://www.cdc.gov/niosh/docs/77-140/. Accessed 18 February 2025.
41. Braz LG, Braz JRC, Cavalcante GAS, et al. [Comparison of waste anesthetic gases in operating rooms with or without an scavenging system in a Brazilian University Hospital]. Rev Bras Anestesiol. 2017; 67: 516-520.
42. American Society of Clinical Oncologists. 2025. https://ascopubs.org/doi/10.1200/OP.23.00637#:~:text=Oncology's%20Impact%20on%20Climate%20Change oace. Accessed 18 February 2025.

43. Fine RE, Gilmore RC, Tomkovich KR, et al. Cryoablation Without Excision for Early-Stage Breast Cancer: ICE3 Trial 5-Year Follow-Up on Ipsilateral Breast Tumor Recurrence. Ann Surg Oncol. 2024; 31: 7273-7283.
44. Cheung WS, She WH, Tsang SHY, et al. Comparison of radiofrequency ablation, microwave ablation and high-intensity focused ultrasound for hepatocellular carcinoma: a retrospective study. HPB (Oxford). 2025. S1365-182X(25)00003-6.
45. Zou YW, Ren ZG, Sun Y, et al. The latest research progress on minimally invasive treatments for hepatocellular carcinoma. Hepatobiliary Pancreat Dis Int. 2023; 22: 54-63.
46. Pasquer A, Ducarroz S, Lifante JC, et al. Operating room organization and surgical performance: a systematic review. Patient Saf Surg. 2024; 18: 5.
47. Iwasaki Y, Shimada J, Kato D, et al. Improvements in thoracic surgery outcomes: a multi-institutional collaboration study. J Cardiothorac Surg. 2015; 10: 30.
48. Climate Change. 2025. https://www.climatexchange.org.uk/projects/examples-of-noregret-low-regret-and-win-win-adaptation-actions/. Accessed 18 February 2025.
49. Cho Y, Withana PA, Rhee JH, et al. Achieving the sustainable waste management of medical plastic packaging using a life cycle assessment approach. Heliyon. 2024; 10: e38185.
50. Kagoma YK, Stall N, Rubinstein E, et al. People, planet and profits: the case for greening operating rooms. CMAJ. 2012; 184: 1905-1911.
51. Baker S, Clark J, Pla AB, et al. Neptune versus canister-based surgical waste management in Europe: results of the GREEN study. Ann Med Surg (Lond). 2023; 85: 4307-4314.
52. Nanashima A, Abo T, Takagi K, et al. Clinical significance of vessel-sealing device usage for pancreatectomy: a retrospective cohort study. Hepatogastroenterology. 2014; 61: 1767-1774.
53. Shibao K, Honda S, Adachi Y, et al. An advanced bipolar device helps reduce the rate of postoperative pancreatic fistula in laparoscopic gastrectomy for gastric cancer patients: a propensity score-matched analysis. Langenbecks Arch Surg. 2022; 407: 3479-3486.
54. Lee WJ, Chen TC, Lai IR, et al. Randomized clinical trial of Ligasure versus conventional surgery for extended gastric cancer resection. Br J Surg. 2003; 90: 1493-1496.
55. Kwakye G, Pronovost PJ, Makary MA. Commentary: a call to go green in health care by reprocessing medical equipment. Acad Med. 2010; 85: 398-400.
56. Government Accountabilbity Office. 2025. GAO-08-147 Reprocessed Single-Use Medical Devices: FDA Oversight Has Increased aAIDNITUPaEHR. Accessed 18 February 2025.
57. Kuvaldina A, Hayes G, Sumner J, et al. Influence of multiple reuse and resterilization cycles on the performance of a bipolar vessel sealing device (LigaSure) intended for single use. Vet Surg. 2018; 47: 951-957.
58. Loftus TJ. A Comparison of the Defect Rate Between Original Equipment Manufacturer and Reprocessed Single-Use Bipolar and Ultrasound Diathermy Devices. ASME J Med Devices. 2015; 9(4): 044501.
59. Meissner M, Hafermann J, Silas U, et al. Evaluating the Environmental Impact of Single-Use and Multi-Use Surgical Staplers with Staple Line Buttressing in Laparoscopic Bariatric Surgery. Risk Manag Healthc Policy. 2023; 16: 1423-1433.
60. Bolten A, Kringos DS, Spijkerman IJB, et al. The carbon footprint of the operating room related to infection prevention measures: a scoping review. J Hosp Infect. 2022; 128: 64-73.
61. McQuerry M, Easter E, Cao A. Disposable versus reusable medical gowns: A performance comparison. Am J Infect Control. 2021; 49: 563-570.
62. van Nieuwenhuizen KE, Friedericy HJ, van der Linden S, et al. User experience of wearing comfort of reusable versus disposable surgical gowns and environmental perspectives: A cross-sectional survey. BJOG. 2024; 131: 709-715.
63. Yap A, Wang K, Cornejo J, et al. Transition to Reusable Surgical Gowns at a Hospital System. JAMA Netw Open. 2023; 6: e2330246.
64. Scheinker D, Hollingsworth M, Brody A, et al. The design and evaluation of a novel algorithm for automated preference card optimization. J Am Med Inform Assoc. 2021; 28: 1088-1097.

65. Weiss A, Hollandsworth HM, Alseidi A, et al. Environmentalism in surgical practice. Curr Probl Surg. 2016; 53: 165-205.
66. Embick E, Bieri M, Koehler TJ, et al. Cost containment: an experience with surgeon education and universal preference cards at two institutions. Surg Endosc. 2020; 34: 5148-5152.
67. Bravo D, Thiel C, Bello R, et al. What a Waste! The Impact of Unused Surgical Supplies in Hand Surgery and How We Can Improve. Hand (NY). 2023; 18: 1215-1221.
68. Crippa M, Solazzo E, Guizzardi D, et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nat Food. 2021; 2: 198-209.
69. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. Science. 2018; 360: 987-992.
70. Shukla PR, Skea J, Slade R, et al. IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.
71. Dubois G, Sovacool B, AallC, et al. It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. Energy Res Soc Sci. 2019; 52: 144-158.
72. Sadowski M, L. Perkins, E. McGarvey. Roadmap to Net-Zero: Delivering Science-Based Targets in the Apparel Sector. Working Paper. Washington, DC: World Resources Institute. 2021.
73. Khattab TA, Abdelrahman MS, Rehan M. Textile dyeing industry: environmental impacts and remediation. Environ Sci Pollut Res Int. 2020; 27: 3803-3818.
74. Ritchie H. “Cars p, trains: where do CO_2 emissions from transport come from?” 2020. https://ourworldindata.org/co2-emissions-from-transport. Accessed 18 February 2025.
75. Hall D, Lutsey N. Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions. The International Council on Clean Transportation; 2018:1-12.
76. Koroma MS, Costa D, Philippot M, et al. Life cycle assessment of battery electric vehicles: Implications of future electricity mix and different battery end-of-life management. Sci Total Environ. 2022; 831: 154859.
77. Greenpeace. 2022. https://www.greenpeace.org/usa/circular-claims-fall-flat-again/. Accessed 18 February 2025.
78. US Environmental Protection Agency. 2025. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data. Accessed 18 February 2025.
79. Benson AB, Venook AP, Adam M, et al. Colon Cancer, Version 3.2024, NCCN Clinical Practice Guidelines in Oncology. J Natl Compr Canc Netw. 2024; 22.
80. Wille-Jørgensen P, Syk I, Smedh K, et al. Effect of More vs Less Frequent Follow-up Testing on Overall and Colorectal Cancer-Specific Mortality in Patients With Stage II or III Colorectal Cancer: The COLOFOL Randomized Clinical Trial. JAMA. 2018; 319: 2095-2103.
81. Snyder RA, Hu CY, Cuddy A, et al. Association Between Intensity of Posttreatment Surveillance Testing and Detection of Recurrence in Patients With Colorectal Cancer. JAMA. 2018; 319: 2104-2115.
82. Martin M, Mohnke A, Lewis GM, et al. Environmental Impacts of Abdominal Imaging: A Pilot Investigation. J Am Coll Radiol. 2018; 15: 1385-1393.
83. McAlister S, McGain F, Petersen M, et al. The carbon footprint of hospital diagnostic imaging in Australia. Lancet Reg Health West Pac. 2022; 24: 100459.
84. Johnson PM, Lin DJ, Zbontar J, et al. Deep Learning Reconstruction Enables Prospectively Accelerated Clinical Knee MRI. Radiology. 2023; 307: e220425.
85. Haggenmüller S, Maron RC, Hekler A, et al. Skin cancer classification via convolutional neural networks: systematic review of studies involving human experts. Eur J Cancer. 2021; 156: 202-216.

86. Hekler A, Utikal JS, Enk AH, et al. Superior skin cancer classification by the combination of human and artificial intelligence. Eur J Cancer. 2019; 120: 114-121.
87. Maron RC, Weichenthal M, Utikal JS, et al. Systematic outperformance of 112 dermatologists in multiclass skin cancer image classification by convolutional neural networks. Eur J Cancer. 2019; 119: 57-65.
88. Perincheri S, Levi AW, Celli R, et al. An independent assessment of an artificial intelligence system for prostate cancer detection shows strong diagnostic accuracy. Mod Pathol. 2021; 34: 1588-1595.
89. Sinha S, Vegesna R, Mukherjee S, et al. PERCEPTION predicts patient response and resistance to treatment using single-cell transcriptomics of their tumors. Nat Cancer. 2024; 5: 938-952.
90. Luccioni AS VS, Ligozat AL. Estimating the carbon footprint of BLOOM, a 176B Parameter Language Model. J machine learning research. 2022. DOI:10.48550/arXiv.2211.02001.
91. Kotcher J, Maibach E, Miller, J et al. Views of health professionals on climate change and health: a multinational survey study. Lancet Planet Health. 2021; 5: e316-e323.
92. WHO global strategy on health, environment and climate change: the transformation needed to improve lives and wellbeing sustainably through healthy environments. Geneva: World Health Organization. 2020. https://www.who.int/publications/i/item/9789240000377. Accessed 18 February 2025.
93. Working Group on Health in Climate Change (HIC) of the Environment and Health Process (EHP) in Europe. In: Climate change Copenhagen: WHO Regional Office for Europe. 2021. https://www.euro.who.int/en/health-topics/environment-and-health/Climatechange/policy/working-group-on-health-in-climate-change-hic-of-the-environment-and-health-process-ehp-in-europe. Accessed 18 February 2025.
94. Working Group on Health in Climate Change (HIC) of the Environment and Health Process. https://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/policy/working-group-on-health-in-climate-change-hic-of-the-environment-and-health -process-ehp-in-europe. Accessed 18 February 2025.
95. O'Reilly S, Lynch E, Hwang ES, et al. Climate Therapy: Sustainability Solutions for Breast Cancer Care in the Anthropocene Era. Clin Breast Cancer. 2024.
96. Joint Commission. Sustainable Health Care. 2025. https://www.jointcommission.org/our-priorities/sustainable-healthcare/. Accessed 18 February 2025.
97. Koh HK, Bantham A, Geller AC, et al. Anchor Institutions: Best Practices to Address Social Needs and Social Determinants of Health. Am J Public Health. 2020; 110: 309-316.
98. Ledda V, Adisa A, Agyei F, et al. Environmentally sustainable surgical systems. BMJ Glob Health. 2024; 9.