Institute *for* Healthcare Improvement

Accelerating Decarbonization in Clinical Care

Implementation Guide

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Institute for Healthcare Improvement

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Introduction

The climate emergency is the single greatest public health challenge of the 21st century.[1] At current emission rates, climate change is projected to cause 250,000 additional deaths per year globally between 2030 and 2050. That could increase to 1.5 million deaths per year by 2100.[2,3]

The effects of climate change also act as a threat multiplier, compounding inequities in access to and quality of care along racial, ethnic, gender, and socioeconomic lines.[4]

The health care sector is a significant contributor to the climate crisis, accounting for about ten percent of total greenhouse gas (GHG) emissions in the United States.[5] Health care organizations must rapidly develop approaches to reduce their contributions to environmental emissions that are threatening life on the planet — and lead the response to climate change through their example.

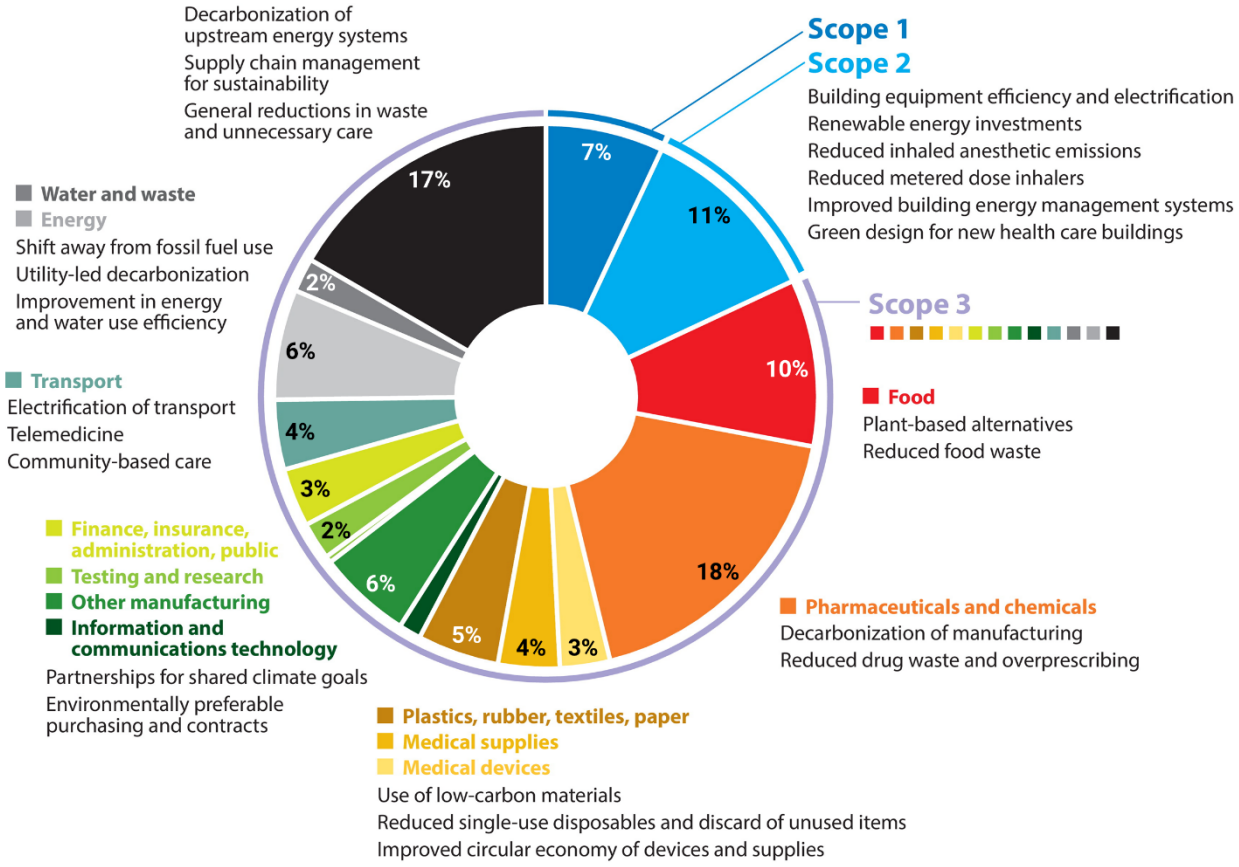
Greenhouse Gas Protocol

The Greenhouse Gas Protocol (GHGP), the global standard for quantifying and reporting on GHG emissions, organizes emissions into three categories (or Scopes) based on their source.[6]

- Scope 1: Direct emissions from owned or directly controlled sources
- Scope 2: Indirect emissions from the generation of purchased energy
- Scope 3: All other indirect emissions, such as those that occur in producing or transporting goods and services across the supply chain

Figure 1 shows greenhouse gas emissions generated by health care in the US, organized by Scope.

Figure 1. US National Health Care Greenhouse Gas Emissions by GHGP Scopes[7]



Key Strategies for Health Care Decarbonization

In 2022, commissioned by the Agency for Healthcare Research and Quality (AHRQ), the Institute for Healthcare Improvement (IHI) collaborated with experts in health care sustainability, clinical practice, and health system leaders to develop a unified theory of change, measurement framework, and set of evidence-based, system-level clinical and operational interventions to reduce the carbon footprint of health care systems.

IHI researchers engaged the National Academy of Medicine's Action Collaborative on Decarbonizing the US Health Sector, Health Care Without Harm (HCWH), and other national experts to ensure alignment with existing efforts and to pressure test measures, interventions, and emerging insights in the research process.

The resulting report, *Reducing Healthcare Carbon Emissions: A Primer on Measures and Actions for Healthcare Organizations to Mitigate Climate Change*,[8] serves as the foundation for IHI's work in 2023 to bring decarbonization theories into action. Figure 2 provides a summary of key measures and strategies from this report.

Figure 2. Summary of Key Measures and Strategies for Health Care Decarbonization[9]

High-Level Aim: Reduce organizational emissions by 50 percent by 2030 and to net zero by 2050

	High-Priority Measures		Key Strategies	
	Core Measures	Elective Measures	Reduce Waste	Reduce Emissions Intensity
Building Energy	• Total GHG emissions from energy use	• Energy use intensity of health care facilities • ENERGY STAR® score of health care facilities	• Conserve and optimize energy efficiency	• Transition to zero-carbon fuel sources • Meet and exceed the current green building/retrofitting standards
Transportation	• Total GHG emissions of owned and leased vehicles	• Total GHG emissions from staff and patient travel	• Centralize oversight to actively manage transportation reduction	• Transition to sustainable transportation systems
Anesthetic Gas	• Total GHG emissions from inhaled anesthetics	• Mean fresh gas flow rates	• Minimize fresh gas flow rates • Decommission or avoid construction of central nitrous oxide piping	• Manage anesthetic choices
Pharmaceuticals and Chemicals	Overarching Scope 3 Measure: • Total GHG emissions from (or total spend on) goods and services	• Metered-dose inhaler outpatient prescriptions as a percentage of all inhaler prescriptions	• Prevent disease exacerbation • Launch appropriate use campaigns	• Maximize lower carbon alternatives for inhalers
Medical Devices and Supplies	Overarching Scope 3 Measure: • Total GHG emissions from (or total spend on) goods and services	• Percent purchased goods and services supplied by companies performing carbon disclosures with a science-based target for emissions reduction	• Ensure resource stewardship	• Adopt and expand circular economy policies and practices related to reuse, reprocessing, repair, repurposing, and recycling • Adopt preferential purchasing with suppliers or service providers that perform carbon disclosures and have set a science-based target for decarbonization
Food	Overarching Scope 3 Measure: • Total GHG emissions from (or total spend on) goods and services	• Total GHG emissions from food procurement	• Adopt food waste prevention and diversion programs	• Design plant-forward menus and retail options

Theory of Change for Decarbonizing Clinical Care Delivery

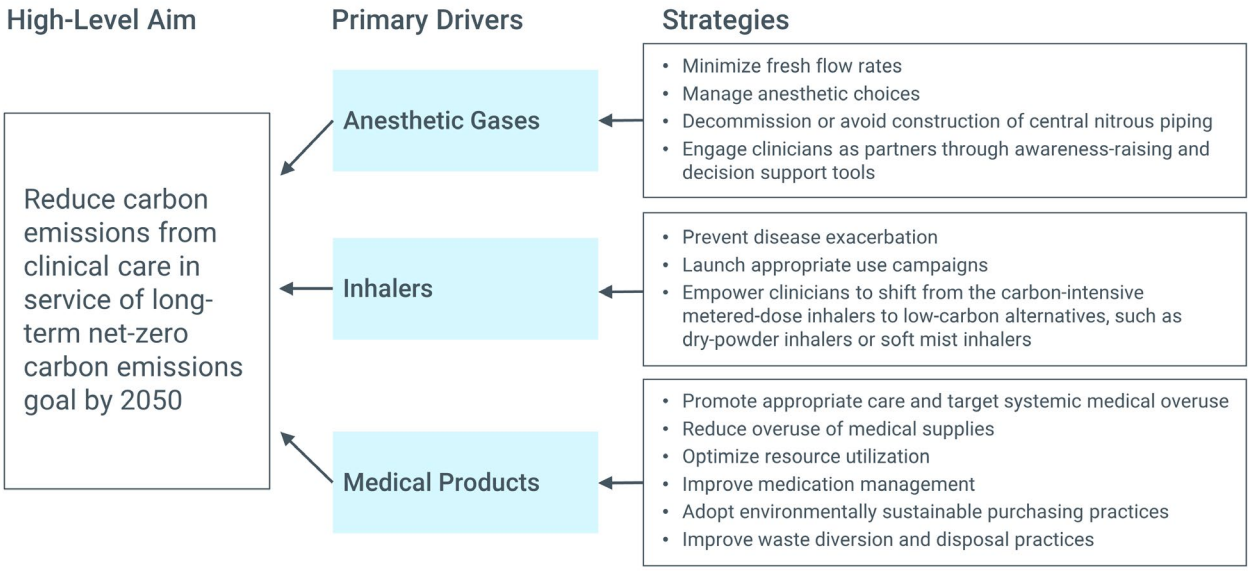
Clinicians play a central role in sustainable care delivery by making informed choices about resources, waste, and GHG emissions. Drawing on the clinical domains identified in Figure 2, IHI partnered with hospitals and health systems to tackle emissions stemming from anesthetic gases, inhalers, and medical supplies and devices (see Figure 3). These clinical domains have significant environmental impact and present clear opportunities for improvement.

- **Anesthetic Gases:** Inhaled anesthetic agents, especially desflurane and nitrous oxide, are potent greenhouse gases that contribute to climate change. Mounting evidence suggests that using less harmful agents can achieve more sustainable anesthetic care.[10,11,12]

- **Inhalers:** The choice of inhalers for patients with respiratory diseases, such as asthma and chronic obstructive pulmonary disease, also plays a role. Metered-dose inhalers (MDIs) contain hydrofluorocarbons (HFCs), another powerful GHG, as propellants. As an alternative, when appropriate, clinicians may prescribe dry powder inhalers (DPIs), which do not contain HFCs, as well as ensure proper disposal of MDIs.

- **Medical Products:** Clinicians also can reduce the environmental impact by choosing medical products with lower embodied carbon, which refers to the carbon related to extraction, production, manufacturing, use, and disposal of the product.[13]

Figure 3. Drivers of Decarbonizing Clinical Care



Anesthetic Gases

Anesthetic gases are primarily used in the operating room (OR), labor and delivery (L&D), and outpatient surgical centers. During surgical procedures using anesthetic gases, the unused agents — roughly 95 percent of the gas used per case — are exhaled from the patient, scavenged from the immediate clinical setting, and vented out of the building's roof into the atmosphere and outside air of local communities.

Nitrous oxide, desflurane, sevoflurane, and isoflurane are the most common anesthetic gases used for patient care in the United States (see Table 1). These agents are potent GHGs.

Table 1. Anesthetic Gas Conversions (provided by Jonathan E. Slutzman)[14]

Anesthetic Gas	Dosage	Emission Intensity	Abbreviation
Nitrous oxide	2.205 lbs/kg	273 kg CO2e*/kg	N2O
Sevofluorane	0.00152 kg/mL	144 kg CO2e/kg	Sev
Isofluorane	0.0015 kg/mL	510 kg CO2e/kg	Iso
Desflurane	0.00146 kg/mL	2540 kg CO2e/kg	Des

*CO2e: Carbon dioxide equivalent, a measure used to compare the emissions from various greenhouse gases based on their global warming potential

The IHI Decarbonizing Care Learning Community identified improvement strategies and change ideas to reduce GHG emissions from anesthetic gases (see Table 2).

Table 2. Anesthetic Gases: Improvement Strategies and Change Ideas

Strategies	Change Ideas
Minimize fresh flow rates	• Lower default fresh gas flow settings
Manage anesthetic choices	• Replace desflurane with sevoflurane or isoflurane, eventually reducing or removing desflurane from formularies • Transition to Total Intravenous Administration (TIVA) where possible
Decommission or avoid construction of central nitrous piping	• Substitute central nitrous piping — which can leak at rates of 90% — with portable E-cylinders • Ensure nitrous oxide tanks are closed between usage to avoid leaks
Engage clinicians as partners through awareness-raising and decision support tools	• Enlist anesthesiologists to champion this work • Use real-time data from the electronic health record (EHR) to inspire healthy competition • Offer regular feedback to anesthesia groups about emissions data, lowest emitters, and tips on how to decrease emissions • Implement provider guidance into clinical workflow such as vaporizer labels at the point of decision-making, GHG footprint to order entry system, or "traffic light" color coding to indicate environmental impacts[7,10] • Offer education on reducing emissions from anesthetic gases to existing employee trainings, presentations, and rounds

Considerations

Improvement teams should anticipate the following:

- In select cases, specific anesthetics are preferred for given patient circumstances (e.g., pre-existing conditions, body habitus). Partnering with clinicians is critical to ensure their confidence with changes in anesthetic choices.
- Reducing use of desflurane requires working closely with procurement on vendor contracts — for example, to prevent automatic re-ordering of supplies.
- Operational logistics are key to decommissioning nitrous oxide, including planning for storage of cannisters and reviewing local regulations to ensure compliance (e.g., with required fire department inspections).

Examples of Successful Improvements

Health care systems such as Massachusetts General Hospital and Seattle Children's Hospital provide their clinicians with monthly performance reports in the context of climate change. For example, nurse anesthetists and anesthesiologists at Mass General receive monthly climate

assessments: the global warming footprint of the gases they choose, and whether they are reducing the flow or amount of gas used.

Seattle Children's Hospital began sending monthly reports to its anesthesiologists in December 2021. In conjunction with these emails, an earlier education campaign, and new protocols, the health system has reduced GHG emissions associated with anesthesia by 87 percent as compared to five years ago.[1]

Health systems have tested other improvements to reduce GHG emissions from anesthetic gases, as described below.

Stanford Health Care

604 licensed beds | 99 clinical/non-clinical sites | California

A clinician-led improvement team set an aim of reducing emissions from nitrous oxide (N2O) across the health system. Their analysis comparing purchased amounts of N20 with usage data from the electronic health record demonstrated that less than 9.5 percent of N20 was used in patient care — and that more than 90 percent is being lost through leakage in the centrally piped system.

As its first test, the health system chose to replace the centrally piped N2O system with E-cylinders in a pilot site with eight operating rooms (ORs). The team also assessed storage capacity and inventory in the E-cylinders to ensure uninterrupted patient access to N2O.

To decommission the central N20 supply system at the pilot site, systems were disconnected at the central manifold or tank farm and the individual zone distribution valves. At the point of use, blank plates were installed for the wall outlets and the boom outlets on the anesthesia machine. The utility system pressure alarms at various locations and the central supply line alarms at the anesthesia machine were deactivated.

Prior to implementing this change, anesthesia staff received educational reminders to use both N2O from portable E-cylinders and low fresh gas flows. One lead physician also reached out directly to surgeons who operate at the pilot site to inform them of the initiative and get their buy-in.

The E-cylinders in the eight ORs were turned off at the end of day to minimize any leaks during the five-week pilot period. The E-cylinders were weighed using a scale at the end of each week to calculate the amount of N2O remaining. The N2O usage amount obtained from the E-cylinders was then compared with the amount of N2O used on patients obtained from the EHR. The two usage numbers aligned almost completely, verifying that there was no loss of N2O when using E-cylinders.

Collaboration among different stakeholders across Stanford Health Care — facilities staff, engineering staff, anesthetic technicians, and health care providers — was instrumental in the success of this pilot. Plans are underway to scale this approach across the health system.

Northern Light Health

800 beds | 10 hospitals | Maine

With the support of several senior leaders at Northern Light Eastern Maine Medical Center — including the senior vice president and chief quality officer; vice president of facilities, sustainability, and supply chain; and the chief of anesthesia — a survey was administered to 87 anesthesiologists at the system's flagship hospital to assess anesthetic preferences related to desflurane. The survey feedback indicated that while some providers have no strong feelings regarding desflurane use, others feel strongly that desflurane is the best anesthetic for use in certain clinical cases. It also indicated that several providers lacked a clear understanding or awareness of the environmental impacts of desflurane.

Rather than pursuing a top-down approach of simply eliminating access to desflurane, the team opted to slow the process, engage anesthesia providers to share their concerns, and educate them on the environmental impacts of desflurane. This approach led to greater understanding of the reasons for phasing out desflurane, which increases the likelihood of long-term success and employee satisfaction. At the medical center, surgical cases using desflurane were reduced by half in 2023 and, combined with a reduction in desflurane purchases and a rollout of the clinical engagement process to other hospitals, Northern Light is poised to achieve the system goal of reducing desflurane use by 50 percent in FY2024.

Additional Resources

Note that some Practice Greenhealth resources are available only to members.

- Practice Greenhealth Anesthetic Gas Toolkit
- Practice Greenhealth Sustainability Benchmark Report

Inhalers

Propellants in metered dose inhalers (MDIs) are potent greenhouse gases. MDI prescriptions can account for 3 percent of a health system's footprint.[15] In the US, annual emissions from MDIs are similar to those from 500,000 automobiles driven for a year.

The IHI Decarbonizing Care Learning Community identified improvement strategies and change ideas to reduce GHG emissions from inhalers (see Table 3).

Table 3. Inhalers: Improvement Strategies and Change Ideas

Strategies	Change Ideas
Prevent disease exacerbation	• Offer preventive care and disease management to reduce the incidence and severity of asthma, chronic obstructive pulmonary disease, and bronchitis — thus reducing need to manufacture and prescribe inhalers
Launch appropriate use campaigns	• Partner with patients to avoid unnecessary use of inhalers

Empower clinicians to shift from MDIs to low-carbon alternatives, such as dry-powder inhalers (DPIs) or soft mist inhalers	• Invest in clinician education on the appropriate use of DPIs and their comparable efficacy to MDIs • Conduct a detailed formulary review of propellent-based GHG emissions for each inhaled medication formulation • Implement cost comparison and GHG-equivalent labeling • Develop and circulate criteria for appropriate patient selection • Employ electronic health record (EHR) interventions to encourage clinicians to prescribe smaller propellant volume/actuation inhalers (e.g., Ventolin and its generic equivalent, albuterol)

Considerations

Improvement teams should anticipate the following:

- Given hundreds of products and formulations, changing to lower-carbon inhalers is vastly more complex than lowering emissions from anesthetic gases, where there are four primary anesthetic options. In prescribing inhalers, clinicians are treating patients with different diseases and varying levels of severity, co-occurring conditions, and social factors. Improving care quality for patients with asthma and other respiratory diseases is an important upstream intervention that also reduces the need for pharmaceuticals and inhalers.
- Partnering with pharmacy, procurement, supply chain, and payers can enable affordable access to lower-carbon alternatives and help avoid increasing out-of-pocket costs for patients.
- Implementation of new decision support tools may exacerbate existing clinician burdens such as alarm fatigue.

Example of a Successful Improvement

Mass General Brigham

Large integrated health system serving 2.6 million patients | Massachusetts

Two medical directors of sustainability implemented an initiative to meaningfully reduce greenhouse gas emissions from MDIs while improving care for patients with asthma. They recognized that changing prescribing practices would be complex given several factors: entrenched clinical approaches to asthma and chronic obstructive pulmonary disease management; evolving treatment guidelines; cost considerations for patients given insurance formularies; and limited awareness among clinicians of the environmental harms of MDIs.

The medical directors first engaged stakeholders across the system to facilitate buy-in and capitalize on deep institutional knowledge. The interdisciplinary team includes clinicians from specialties that predominantly prescribe MDIs (primary care, pulmonology, allergy and immunology, and emergency medicine), pharmacists, a respiratory therapist, and members of the value-based care and quality and safety teams, with representatives from multiple hospitals and the health plan.

After an initial kickoff meeting for introductions, delineation of the problem, and discussion of goals, the interdisciplinary team began defining potential levers for intervention. A facilitated exercise using Google Jamboard was used to brainstorm potential approaches. The list of approaches was subsequently narrowed based on perceived feasibility and impact as well as a desire to identify strategies that could be implemented at the health system level, rather than through broader advocacy efforts focused on state and federal policy.

The interdisciplinary team prioritized the following activities:

- **Identify patients who might benefit from improved asthma control: Develop EHR tools to inform inhaler prescribing practices.** The team is developing Best Practice Alerts (BPAs), SmartRxs (prescribing pathways for a specific clinical condition linked to a specific medication order in the EHR), and strategies to use the prescription refill process to encourage inhalers that are less harmful to the environment and more effective as an opportunity to identify patients who might benefit from improved asthma control and asthma care.
- **Offer training for new EHR tools: Educate prescribers about low-emission asthma care.** Create a series of educational sessions with each specialty using a standard slide deck for consistent messaging to ensure that clinicians have the appropriate contextual information for the proposed EHR updates.
- **Develop standardized patient education materials.** These resources will help clinicians communicate about the climate impact of inhalers and offer patients guidance about use of low-emission inhalers.

Next steps include defining the content of the tools embedded in the EHR; coordinating implementation with other operational units that oversee the EHR and population health programs; and future educational sessions with different specialties across multiple hospitals to catalyze a larger discussion.

Medical Products

Material waste is produced at all phases of direct care in clinical units and patient care support, typically categorized within multiple streams: municipal solid waste or landfill, regulated medical waste, and hazardous waste. All purchased materials and supplies for use in providing or supporting direct patient care contribute to this waste, particularly single-use items.

Medical devices and supplies contribute approximately 7 percent of US health care sector GHG emissions.[16,17] Analysis of national- and institution-level data and insights from experts surface four priorities for reducing GHG emissions in this area:

- **Surgical products:** Operating rooms are resource-intensive, with high energy demands, consumable throughput, and waste volumes. In a small example of the sheer volume of waste, one institution found that an estimated 80 percent of surgical instruments went unused in their OR.[18]

- **Diagnostic imaging:** Diagnostic testing contributes an estimated 9 percent of health care's carbon footprint.[19] Magnetic resonance imaging (MRI) and computerized tomography (CT) have particularly large carbon footprints compared to x-ray and ultrasound. The majority of MRI and CT emissions are attributed to electricity use, particularly standby power use.
- **Medical apparel and textiles:** As high-volume products with substantial embedded emissions in manufacturing, distribution, and disposal, medical apparel and textiles present an important opportunity. Switching to reusable products has the potential to reduce GHG emissions from apparel and textiles by 66 percent.[20]
- **Pharmaceutical waste:** The carbon emissions of pharmaceuticals are consistently calculated to be among the top contributors to health care's environmental impact, accounting for 18 percent of health care's carbon footprint in the US.[21] By targeting overprescription and pharmaceutical waste, health systems can shift to more sustainable care delivery practices and inflect this major source of GHG emissions.

The IHI Decarbonizing Care Learning Community identified improvement strategies and change ideas to reduce GHG emissions from medical products (see Table 4).

Table 4. Medical Products: Improvement Strategies and Change Ideas

Strategies	Change Ideas
Promote appropriate care and target systemic medical overuse	• Track and identify patterns of low-value care across the system[22] • Develop de-implementation strategies to reduce inappropriate care[23,24,25] • Adopt and promote recommendations advanced by Choosing Wisely, the Right Care Alliance, and Wiser Healthcare[26,27,28,29,30] • Reduce clinically unnecessary laboratory and imaging tests[31,32] • Limit prescription durations and refills to discourage overprescribing[33] • Adopt social prescribing practices, such as linking patients to community services, and green prescribing time in nature and access to local foods[34,35] • Provide clinicians with best practice decision support tools, promoting appropriate choices of therapeutic and diagnostic interventions[36,37] • Promote carbon literacy and "life cycle thinking" in health care leadership and workforce • Encourage leaders to include environmental costs and life cycle thinking in value analysis • Include life cycle analysis and device and supply kg/CO2 in vendor selection criteria • Promote educational material on carbon literacy and life cycle thinking with staff
Reduce overuse of medical supplies	• Transition to reusable linens in all settings and reusable surgical gowns in ORs, L&D units, and outpatient surgery centers

	• Phase out automatic supply stocking in patient rooms and institute isolation room policies that avoid in-room stocks • Convert to reusable surgical instruments[38] • Reduce and reuse textiles and protective clothing[39,40,41] • Use reusable hard cases for surgical instrumentation instead of blue sterilization wrap[42,43,44,45] • Reprocess FDA-approved single-use medical devices[46] • Reduce the use of consumables through shifting to reusable surgical trays, patient padding, and suction receptacles[47]
Optimize resource utilization	• Reformulate OR kits, using an evidence-based approach to standardizing the number and types of items included[48,49,50,51] • Convert to reusable, reprocessable, or hybrid surgical instruments[52,53,54] • Adopt an as-needed *pro re nata* (PRN) model for non-emergent cases, opening a minimal base set of instruments preoperatively with potential necessary instruments present in the room unopened, with the option to unpackage them[55] • Maximize medical device reprocessing programs • Change imaging to a lower carbon modality when clinically appropriate[56] • Turn off scanners, workstations, ventilation, and scavenging systems when they are not in use, ensuring safety powerup protocols[57] • Optimize utilization rates on existing equipment to minimize idle time before purchasing new equipment[58,59] • Implement capital equipment take-back programs, including purchasing refurbished equipment[60]
Improve medication management	• Optimize patient adherence to prescriptions to minimize need for subsequent treatments[61] • Reduce waste from unused medication through deprescribing campaigns[62] • Conduct medication returns audits and safe disposal[63] • Conduct a regular review of polypharmacy and duplicative prescriptions[64] • Enact multi-dosing policies for topical drugs, where appropriate • Design effective channels for unused medicine retrievals/collections from hospital wards[65] • Enact policies that permit discharging patients with their opened and unused medications from treatment spaces • Minimize dose packaging to reduce drug waste, where feasible
Adopt environmentally sustainable purchasing practices	• Expand policies related to reuse, reprocessing, repair, repurposing, and recycling • Adopt a “reusables-first” procurement policy • Embed purchasing criteria into RFIs/RFPs that state a preference for companies that perform transparent, standardized GHG inventories and adhere to science-based decarbonization targets[66]

	• Develop and implement a system-wide Environmentally Preferable Purchasing (EPP) policy[67,68]
Improve waste diversion and disposal practices	• Perform appropriate waste segregation to minimize unnecessary high-emissions waste treatment[69,70,71] • Decrease regulated medical waste (RMW) and hazardous waste where possible • Maximize recycling potential of supplies and materials such as aluminum and paper[72] • Implement recycling and composting to decrease municipal solid waste streams • Collect only appropriate unused medical supplies for donation and responsible redistribution[73]

Considerations

Improvement teams should anticipate the following:

- It's important to partner with infection prevention control (IPC) to advance decarbonization efforts while maintaining safety and quality standards. Drawing upon this expertise can ensure that sustainability-associated risks, tangible and perceived, are identified and circumvented with evidence-based practices and that appropriate IPC policies are implemented to support decarbonization efforts.[13]
- Staff and equipment availability is neccesary for cleaning, disinfecting, and sterilizing reusable equipment to identify reuse or reprocessing opportunities.
- New processes require engaging with surgical services staff, environmental services, sterile reprocessing, laundry, and training staff.
- To ensure that a reusable device has a lower CO2e impact than the single-use product it replaces, conduct a life cycle analysis (LCA). Calculate production burden and CO2e cost for refurbishing and transport, as well as the number of times the device can be refurbished.

Additional Resources

- HealthcareLCA[6]: Provides a comprehensive database of health care life cycle analyses
- Carbon Literacy Project's Carbon Literacy Toolkit for Healthcare (available upon request from the UK National Health Service)
- Practice Greenhealth's Implementation Module, Medical Device Reprocessing

Example of a Successful Improvement

Northwest Permanente

1,500 physician multispecialty group practice | Oregon and Southwest Washington

Northwest Permanente, affiliated with Kaiser Permanente, was the one of the first medical groups in the United States to publish a Climate Action Plan and become a certified B

Corporation, demonstrating their commitment to caring for people and planet. Leaders launched an improvement initiative called “Wait, Don't Waste,” with an aim of reducing waste from surgical supplies in the OR. This work requires strong teamwork and communication among surgeons, surgical assistants, circulating nurses, inventory management staff, and case pickers.

The key principles are:

- Never open something that is not used.
- Never open disposable items prior to a discussion among surgeon, nurses, and techs.
- Frequently update procedure cards to eliminate rarely used items.
- Opened but unused items should not inspire blame, but should be seen as an opportunity.

Improving procedure cards involves review by the department and individual surgeons, agreement among colleagues to reduce variation, and regular maintenance and updates.

In the first full year of implementation, the program eliminated an estimated 15 metric tons of CO_2 emissions.

Medical Products: Where to start decarbonizing care delivery?

1. Start with indirect patient care items.
    - For example: Reusable sharps containers, reusable fluid management systems (housewide and OR-specific), reusable sterilization containers, patient linens, isolation gowns, and surgical attire
2. Consider more direct patient care items, starting with items that are non-invasive and can be cleaned/disinfected at the point of use.
    - For example: Patient positioning devices, pulse oximetry probes, patient transfer devices, safety belts, EKG leads/cables, grounding pads, warming devices
3. With clinician guidance, address other more direct patient care items that are cleaned, disinfected, or sterilized outside the point of use.
    - For example: Laryngoscope blades and handles, blood pressure cuffs, pneumatic tourniquets, surgical basins, pitchers, cups, towels, light handles
    - Examples in anesthesia care: Supraglottic airways, textiles, breathing circuits[15]

Measurement Guidance

The aim of clinical decarbonization efforts is to reduce greenhouse gas emissions in clinical settings, while reducing cost and maintaining, not compromising on, patient safety.

The primary outcome measures for this work are GHG emissions, measured in carbon dioxide equivalents (CO_2e).

Table 5 includes process or proxy measures that provide insight into whether improvement efforts are moving toward GHG emission reduction.

Free Carbon Emissions Calculators for Health Care Organizations

- ENERGY STAR Portfolio Manager
- Health Care Emissions Impact Calculator (Practice Greenhealth)
- HealthCareGHG.org

Table 5. Potential Measures for Decarbonization in Clinical Care Improvement Efforts

Clinical Domain	Outcome Measure	Proxy or Process Measures
Anesthetic Gases Promote sustainable anesthesia care	Total GHG emissions from inhaled anesthetics	• Anesthesia emissions intensity ($kgCO_2e$/hour) • Total annual purchased and administered volume and cost
Inhalers Improve pharmaceutical administration and prescribing practices	Total GHG emissions from inhalers	• MDI inpatient prescriptions as a percentage of all inhaler prescriptions • Inpatient albuterol prescriptions as a percentage of all MDI inpatient prescriptions
Medical Devices Adopt and expand circular economy policies and practices related to reducing waste and emissions	Total GHG emissions from (or total spend on) goods and services	• Percent purchased goods and services supplied by companies performing carbon disclosures with a science-based target for emissions reduction • Percent of optimized OR procedure packs • Total volume (and cost) of unused supplies in procedures • Reusable items as a percentage of high-impact medical supplies (e.g., gowns, scopes) • Total volume of waste generated

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