SNAPSHOT SERIES
Environmentally Sustainable Opportunities for Health Systems

OPERATING ROOMS (ORs)

ISSUE
Operating rooms (ORs) are key sites for patient care. However, these energy and waste intensive spaces also have a negative impact on the environment and – consequently – human health (1,2). The OR contributes to environmental degradation in several ways. A life cycle assessment of the environmental impacts arising from hysterectomy surgery, for example, found that the major sources of OR emissions were disposable materials and single-use surgical devices; energy used for heating, ventilation, and air conditioning; and anesthetic gases (3,4). Other sources of the OR’s environmental impact include biohazardous medical waste such as fluids and contaminated materials, with the OR generating up to a third of total hospital waste (2,4,5).

Beyond their environmental costs, medical supplies and energy spending in the OR also represent a major financial cost to hospitals, accounting for 6% of Canadian hospital budgets (6). Implementing strategies to support environmental sustainability in the OR such as those described below presents an opportunity to reduce waste and expenditure, while ensuring sterility and patient safety (5,7,8).

STAKEHOLDERS
Clinicians and the administrators who support them have a critical role to play in improving the environmental sustainability of the OR. Many environmental initiatives involve practice change, which must be led by clinicians and strongly supported by administrators. In addition to leading practice change, clinicians and administrators have a role in advising on and advocating for organizational and facility change – to spread and normalize practice change, and to enable it through shifts in organizational policy, purchasing practice, infrastructural development, and/or facilities management.

This Snapshot highlights the interventions that require clinical leadership and engagement. However, we also identify some of the organizational and facility changes that clinicians and administrators can inform and promote.
OPTIONS

There are several options that may be employed individually or in combination to mitigate the environmental impact of the OR. These options fall into five broad areas:

1. Adoption of environmentally sustainable anesthetic practices
2. Reduction of OR kit waste
3. Reduction of waste
4. Resource Stewardship
5. Organizational and facility change

1. Adoption of environmentally sustainable anesthetic practices

Anesthetic gases, including halogenated inhalation anesthetics such as desflurane and sevoflurane, as well as nitrous oxide, are essential to providing comfortable and safe surgery. These agents are also recognized greenhouse gases (GHGs) and contribute to the environmental impact of healthcare (9).

There are many ways for clinicians and administrators to reduce anesthetic gas emissions.

Key strategies include:

• Measurement of gas use for benchmarking and program monitoring and evaluation
• Choosing anesthetic gases with lower environmental impacts
• Choosing an appropriate carrier gas
• Managing anesthetic technique
• Use of appropriate anesthetic scavenging and recycling technology
• Resource Stewardship

Please refer to our Sustainability Snapshot on anesthetic gases for more information.

2. Reduction of OR kit waste

Many hospitals use industry-prepared surgical kits. However, these kits often contain items not routinely used due to physician preference for certain equipment (5). This leads to “overage” – equipment that is readied ahead of a surgical procedure, but remains unused. These unused items are discarded due to their exposure to potential biohazards during the surgery. This excess waste can be addressed via several strategies. One of these is the reformulation of surgical kits, which has both environmental and cost savings.
A study at Yale-New Haven Hospital itemized unused OR supplies to determine a baseline for overage. The investigators then provided the overage information to nursing and administrative staff to create focused reduction strategies including in-service education, as well as a redesign of surgeon ‘pick lists’ and surgical kits (10). The investigators compared 1318 cases before the strategies were introduced and 1367 cases after implementation and found a 45% reduction in mean-per-case overage.

A surgeon-led team at The University of Minnesota Medical Center Fairview reviewed kits for a port placement procedure for chemotherapy patients and reduced the kit from 44 to 27 items (11). The team then reformulated a thoracotomy kit and complemented their approach with reduction strategies such as using smaller bottles of prep solution and saline. These efforts resulted in a reduction of 5,332 pounds of waste annually, along with cost savings of US $81,278 per year.

A complementary strategy to reformulation is to minimize the use of plastic wraps when formulating kits and instead use rigid reusable sterilization containers, as we discuss in more detail below (5).

Beyond reformulation, another approach to reduce overage is adopting the “just-in-time” model, which relies on the availability of items only as they are required (12). Using this model, surgical items, instrumentation and materials are only opened when there is a reasonable probability of these items actually being used.

A study of the just-in-time approach conducted in the Netherlands predicted it to have a similar safety profile to the currently used “just in case” model (13). Modelling studies have predicted cost savings using the just-in-time approach in supplying laparoscopy instrument sets (14).
3. Reduction of waste

3.1 Single-use medical devices

Historically, many medical devices were made of stainless steel and sanitized in-house at healthcare facilities for repeated use. As medical device manufacturing moved to plastic, concerns about healthcare-associated infections prompted questions about the effectiveness and standardization of in-house processing (16). Manufacturers thus began to label an increasing number of products as single-use (SUD), and in-house processing was discouraged (17).

Studies comparing SUDs and reusables identify opportunity for both environmental and cost savings by using reusable devices (52). For some products, options exist to use a reusable device rather than a single use device (e.g., laryngoscopes). However, reusable devices require medical device reprocessing to ensure adequate infection control (15). Reprocessing can also enable products labeled as single-use devices to be reused multiple times. Reports from the United States Food and Drug Administration have found no evidence that reprocessed devices pose a risk to health (18). A 2018 study on the use of a remanufactured circular mapping catheter used in 100 consecutive patients undergoing an AF ablation found no health risk, only one device malfunction, and a reported cost savings of £30,444 (19). While medical device reprocessing has demonstrable environmental benefits and cost savings, concerns around sterilization and infection prevention persist in some jurisdictions (20–22).

CASE EXAMPLE

The University of Washington Hospitals in Seattle reprocess more than 100 different single-use medical devices and in 2008 alone reportedly diverted 5.8 tons of waste for a savings of US $496,123 (5). Stryker Sustainability Solutions division, a third-party medical device reprocessing company, reports that their reprocessing activities alone diverted 13.2M pounds of waste from landfills and saved their clients $339.5M in supply costs (23).

In Canada, provincial and territorial policies regarding whether a device is eligible for reprocessing are based on the device category (17). Devices are categorized by the risk of infection associated with device use as per the Spaulding Scale, which denotes the “hygiene criticality” of an instrument, with critical devices being those that come into contact with blood or sterile tissues (e.g. surgical forceps); semi-critical as those that come into contact with mucous membranes (e.g. endoscopes); and non-critical as those that come into contact with unbroken skin (e.g. stethoscopes) (17,24). Prince
Edward Island, Newfoundland and Labrador, and all three territories prohibit medical device reprocessing regardless of category, whereas Alberta prohibits reprocessing of semi-critical or critical devices but has an exemption process (17).

Those jurisdictions that allow critical and semi-critical device reprocessing, such as Quebec, British Columbia, New Brunswick and Ontario, do so through third-party processors. These companies are licensed and must act in compliance with Health Canada directives to ensure that their processes are held to the same safety and effectiveness requirements as manufacturers of new devices (25). However, in Ontario, guidance reports that “If there is a discrepancy between the reprocessing level recommended by the manufacturer and the intended use of the instrument by Spaulding’s criteria, the higher level of disinfection/sterilization must be used,” (26).

Globally there is similar variation in reprocessing policies. While the practice is guided by regulation in the United States and Germany, reprocessing surgical instruments is illegal and considered unethical in Australia (7,27). Beyond legalities, commentators have raised concerns about infection control, extending the use of single use items beyond their “lifespan,” chemical or mechanical damage to the product during repeated sterilizations, as well as the environmental impact of water and cleaning supplies for reprocessing instruments (7,27,28). Another important concern is patient perception of reprocessed tools. A study of reprocessed external fixation components in orthopedic surgery conducted at the Boston Medical Center reported 65% (178/248) of eligible patients declined enrolment in the trial due to the use of “refurbished” components (29).

3.2 Waterless Scrubs

Scrubbing in preparation for surgery is essential to infection prevention and control; however traditional scrub techniques contribute to water wastage (30).

CASE EXAMPLE

The Carolinas Medical Centre in the United States observed scrubbing habits and found that water frequently ran non-stop during scrubbing and was left running when the person entered the OR. The Green OR Committee then installed flow meters on OR sinks and estimated that 2.7 million litres of water could be saved using alcohol-based waterless scrub solutions (31).

Alcohol-based waterless hand scrub has been found to be equally safe, effective and acceptable, as well as potentially cost saving, when compared to traditional brush-based scrubbing (32,33).
CASE EXAMPLE
The Carolinas Medical Centre implemented a water-saving campaign and found that at baseline only 22% of surgical staff used waterless scrub, but after promotion over 80% of surgical staff favoured the waterless scrub (33). Beyond the immediate impact on water saving, the initiative also reduced the number of towels requiring washing and processing.

3.3 Reusable Products

There are many opportunities to effect environmental and even cost savings by replacing single-use items with reusable items in the OR, as evidenced by the examples below.

Linens: Surgical linens, including gowns, towels, table and Mayo stand covers, are a major source of OR waste, with one study finding that disposable linens represent 39% of OR waste measured by weight (3). Overall, linens have in turn been estimated to account for 2% of total hospital waste (34). Linens are available as disposable or reusable products, thus offering an opportunity to reduce OR waste. A study in two medical centres in Maryland and Washington D.C. compared reusable to disposable linens and found that surgeons and surgical technicians greatly preferred the reusable linens and rated them highly in terms of comfort, ease of use, and protective properties (35).

CASE EXAMPLE
The University of Maryland Medical Center uses reusable linens in the OR and purchases three different types of reusable surgical gowns which offer varying levels of protection as per the Association of the Advancement of Medical Instrumentation (AAMI) standards for liquid barrier performance (5,36). In 2010 alone this resulted in 138,748 pounds of waste diverted from regulated medical waste streams.

Rigid containers: Blue sterile wrap is another major contributor to OR waste, and may comprise up to 19% of waste generated during a procedure (8). This wrapping is discarded at the beginning of surgery and is often disposed of inappropriately as medical waste (see below). One strategy to reduce the use of blue sterile wrap is to replace it with reusable hard metal cases, also known as rigid reusable sterilization containers, where possible (7).
CASE EXAMPLE

The MetroWest Medical Centre in Massachusetts implemented the use of reusable hard metal cases for sterilization and storage (5). The physician-led Green Team was supported to purchase 211 cases to store 66% of total surgical instrumentation. In the following year this resulted in a 5,606lb reduction in the OR waste stream.

Gel padding: Foam padding, used to mitigate neurologic or pressure injuries, is another source of avoidable OR waste. Disposable grounding pads, while available in multiple sizes to fit the patient, contribute to surgical waste. ORs can opt for reusable grounding pads when employing electrosurgical techniques. Reusable grounding pads disperse electrosurgical energy over a large surface area and limit current flow, while reducing the use of single-use items in the OR (37).

CASE EXAMPLE

The Carolinas Medical Centre replaced disposable foam padding with reusable gel padding as part of a Green OR initiative. This resulted in not only a complete reduction of foam waste but also a cost savings of USD $50,000 per year (31).

Sharps containers: Reusable sharps containers have been common in the United States since their introduction in 1986 and are increasingly common in Canada and other countries. Under a reusable sharps container policy, companies will supply health facilities with reusable containers and exchange reprocessed containers that have been disinfected. This model has environmental benefits; a lifecycle assessment at one hospital found that using reusable sharps containers reduced the annual number of containers manufactured from 34,396 to 1844, and diverted 30.9 tons of plastic and 5.0 tons of cardboard from landfill (38). However, the quality and safety of reusable sharps services is dependent on the disposal company offering the service (39).

3.4 Waste Segregation

Strategies to support waste segregation/streaming include: improving access to waste receptacles, including those for pharmaceutical waste; staff education; and establishing waste segregation strategies during the procedure (4,5). Organizational engagement to promote recycling and repurposing opportunities are critical to the success of these efforts.
An important overarching strategy for reducing waste through improved waste segregation is a waste audit. Guidance on how to conduct waste audits is available from the Canadian Coalition for Green Health Care and Practice Greenhealth in the US.

Below are some specific examples of waste segregation opportunities in the OR.

Minimize the regulated medical waste stream: Operating rooms generate up to a third of total hospital waste (1,2). This includes general, pharmaceutical, clinical, and cytotoxic waste (7). Solid hazardous waste generated in the OR undergoes incineration, a high-energy process, which itself produces greenhouse gas emissions. Waste incineration and processing also involves transportation emissions as the waste is taken to treatment facilities, as well as the resulting methane release from landfills, which further contributes to problematic environmental emissions associated with surgical procedures (7). While the Canadian Council of Ministers of the Environment has recommended national standards for the treatment and disposal of biomedical waste, responsibility falls to individual provinces to ensure that waste is decontaminated before disposal at landfills (40).

Much of the waste generated in the OR may be inappropriately segregated as hazardous waste, and thus does not require high-energy processing. Strategies to minimize overuse of the regulated waste stream in the OR include:

- Diverting non-infectious waste-pre-incision, which may include lining the yellow regulated medical waste bin (41) with a clear bag to capture general waste. This bag is sealed and disposed of before the procedure begins.
- Segregating non-infectious waste after the surgical procedure, which may include having clear bags available for any disposable linens or items that cannot be reprocessed.
- Segregating non-infectious waste during the procedure, which involves having both a regulated medical waste bin and a clear general waste bin available during the procedure.

CASE EXAMPLE
A team of perioperative nurses in a large urban hospital in the United States conducted a “Red Bag Receptacle” content evaluation following one day of surgery for abdominal aortic aneurysm endograft procedures and found that, by weight, up to 92% of discarded biohazardous waste was non-hazardous (8). Similarly, a local Toronto team did an informal review in the Emergency Room and found inappropriate waste segregation. The review team is now developing educational modules to address the behaviour change elements required to support appropriate waste segregation.
Segregation for recycling and repurposing: In addition to avoiding the overuse of the regulated medical waste stream, appropriate waste segregation is important in increasing the potential for recycling of clean plastic waste and battering, and the repurposing of single-use devices, where this is possible.

Surgical set-up produces large amounts of plastic. It has been estimated that 20-25% of both OR and hospital waste by weight is attributable to plastics (42). In instances where reusable alternatives are not feasible, there may be an opportunity to recycle these plastics. Recyclable plastics commonly used in the OR include polypropylene, polyethylene and PVC (43). There are, however, challenges to recycling medical plastics. Plastics may be indicated as recyclable by the manufacturer but whether these are able to be recycled in practice will depend on both the waste hauler contracted by the health facility, as well as the location-specific recycling policies and practices (44).

CASE EXAMPLE
Spectrum Health System in Grand Rapids, Michigan, embarked on a comprehensive OR sustainability initiative and worked in coordination with its existing recycling hauler to examine commonly used OR plastics to determine whether there was a recycling market for the products (5). Items deemed eligible included plastic casing, hard plastic from devices, paper lined with plastic, plastic from surgical gowns, outer casings of syringes, soft plastics from glove wrappers, rigid saline bottles wash basins, and surgical preparation kits. This collaboration resulted in 100 bags per day of waste diverted from landfill.

Recycling batteries: Batteries can often be reused or recycled instead of discarded.

CASE EXAMPLE
The Carolina Medical Centre found that each laparoscopic irrigator at their facility used 8 AA batteries which were discarded after each case. The Green OR Committee implemented a collection and recycling initiative that resulted in 9000 AA, 228 9-volt and 154 C or D batteries – or over 500 pounds of alkaline waste – diverted from landfills in 2010 alone (31). These batteries were then reused by various departments or donated to charities for use. This resulted in a cost savings of USD 9238 per year.
4. Choosing Wisely

A further strategy for reducing the environmental impact of the operating room is to reduce unnecessary surgeries (45). This approach is in line with Choosing Wisely Canada recommendations, which aim to reduce unnecessary testing and procedures (46). For example, clinical guidelines from 2017 discouraged the use of arthroscopic surgery for patients with osteoarthritis (47). These procedures continued to be performed in Ontario, prompting a Quality Based Practice panel review, which verified them to be of limited clinical effectiveness for osteoarthritis (48). Reducing such unnecessary surgeries offers environmental benefits through decreased anesthesia and material use and mitigation of clinical waste, as well as major cost savings for the healthcare system. In the case of knee arthroscopies, a single procedure in Ontario costs $1,300; given that 90% of the 27,000 patients who underwent the procedure in 2013 did so for osteoarthritis, eliminating the use of this procedure for patients for whom it has limited clinical benefit could translate to $31 million in savings (49).

5. Organizational and facility change

Some of the interventions to improve the environmental performance of the OR require organizational and facility changes, which clinicians and managers can inform and promote. These multi-faceted initiatives rely on the involvement of diverse stakeholders.

**CASE EXAMPLE**

At the Carolinas Medical Centre (CMC), a group of surgeons and nurses established a Green Operating Room Committee (GORC) (31). GORC sought to develop sustainability interventions that would not only be cost-neutral, but produce downstream improvements in cost-efficiency. Upon its formation, GORC instituted a green mission statement, and encouraged every employee working in the OR to feel a sense of ownership over/responsibility to this mission. Individual contributions and initiatives were solicited. These initiatives were subsequently grouped into four Green OR Campaigns, including Solid Waste Reduction, OR Recyclables & Reusables, Energy & Water Reduction, and Surplus Donations. Quarterly meetings were held to review the progress of these campaigns, and discuss new ideas. Since its formation in 2008, GORC has diverted a significant amount of medical waste through a variety of its Campaign interventions, including repurposing single-use devices, replacing disposable foam padding with reusable gel pads, donating or redistributing previously discarded batteries, powering down lights and equipment when not in use, and converting from soap to an alcohol-based waterless scrub. A key intervention to reduce waste in the OR involved teaching OR staff which materials were biohazardous.
versus general waste, coupled with increasing the size of the general waste bins while decreasing the size of the red biohazardous waste bins (which were relocated to the corner of the OR). This resulted in a 75% reduction in biohazardous red bag waste with a projected cost savings of US$60,000 per year.

As indicated by the CMC case study cited above, there are various organizational and facility changes that can be geared towards the reduction of waste and/or energy use in the OR, some of which we delve into below.

5.1 Reducing Waste

Surplus donations: One strategy to reduce OR wastage is through partnerships with organizations that coordinate charitable donation of surplus supplies to under-resourced settings. A review of studies on medical equipment donation to low-resource settings highlighted the importance of equitable partnerships, and consideration of the human, material, maintenance and educational resources and environment of the receiving site when considering donation arrangements (50).

CASE EXAMPLE

Organizations such as Not Just Tourists support tourists to bring medical supplies as excess baggage (51). In Toronto, major hospitals including SickKids and University Health Network, amongst others, work with Not Just Tourists to facilitate donations of unopened supplies.

Fluid management systems: Surgical procedures generate large amounts of liquid waste. One surgical procedure may generate over 10L of waste from blood or bodily fluids, with a single OR potentially producing 2 tons of fluid per month (43). The resulting liquid waste must be disposed of. This has traditionally been done by collecting liquid waste in disposable containers using surgical suction canisters and disposing of the contents by manually draining fluids into wastewater streams, or mixing the liquid waste with solidifiers for disposal (4,43).

The first of these methods requires staff to manually pour the contents of suction canisters down the drain, which carries a significant health and safety risk (28). The second disposal process entails adding products to canister contents to solidify them for disposal in the regulated medical waste stream (5). However, this process has received criticism on several fronts: some products take time to solidify the waste, and if the canister is dropped there is still a health and safety risk from splatter;
chemicals such as glutaraldehyde and chlorine used in these products carry exposure risks; the amount of waste produced by disposing of multiple cannisters is significant.

An alternative approach to disposing of liquid waste involves installing closed fluid management systems which empty surgical waste liquids directly into the sanitary sewer. These systems can be hard-plumbed and stationary, or consist of portable stations that use a docking station. This method is less resource intensive because it negates the need for solidifiers and (in some systems) plastic canisters, is safer because staff do not have to come into direct contact with surgical waste liquids or toxic chemical solidifiers, and is less costly because the waste does not need to be processed via the regulated waste stream. **Practice Greenhealth** offers a useful guide to setting up and implementing a fluid management system in the OR.

**CASE EXAMPLE**

In Kalamazoo, Michigan, the Bronson Methodist Hospital implemented a closed fluid management system which diverted 8 tons of regulated medical waste and plastic suction canisters and reported savings of US$7,200 (5).

### 5.2 Reducing energy consumption

There are many different ways in which the environmental performance of the OR can be improved through changes to the facility. Optimizing lighting and HVAC are some of the high impact options that reduce energy consumption and reduce costs (5). Specific strategies include equipping the operating room with LED surgical lighting, which reduces energy use and increases thermal comfort for operating room staff. Occupancy sensors can also serve to reduce energy use by dimming lighting and adjusting HVAC systems to reduce air changes in unoccupied rooms.

**CASE EXAMPLE**

As part of a green OR initiative, the Carolinas Medical Centre implemented a “power down” initiative (31). The implementing committee created guidelines which allowed four operating rooms to run at all times. In unused rooms, staff turned off all anesthesia machines, medical equipment, lights, computers, and radios each evening. The initiative resulted in an estimated USD 33,004 in savings annually and the reduction of 234.3 metric tons of CO₂ emissions.
METHODS STATEMENT

This series provides snapshots on key areas in sustainable healthcare. These snapshots are the result of rapid literature reviews and related desk research with review by content experts where possible. Snapshots are not intended to be comprehensive nor exhaustive. Updates to this document and any comprehensive reviews will be posted on the Centre for Sustainable Health Systems’ website.

VERSION HISTORY

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REFERENCES


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