PROJECT CHARTER

Eliminate Desflurane

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Executive Sponsor:

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Please contact CASCADES@utoronto.ca if you have any questions.

NAVIGATION

Goal & Scope

1 What do you want to achieve?

Eliminate the use of desflurane as an anesthetic agent within the institution as soon as possible.*

**Note: Some institutions have been able to accomplish this in as little as one week!*

2 Define the limits of what you want to be included in the project and consider the environmental impacts you are targeting for change.

Project Scope: Institution-wide (or regional health authority, depending on health system configuration).

Emission Scope: Scope 1; these emissions are direct greenhouse gas (GHG) emissions originating from sources controlled and owned by an organization, such as on-site boilers and certain medical gases.

Problem/Opportunity Statement

3 Briefly state the problem you want to solve or the opportunity you want to realize.

Inhaled anesthetic agents are responsible for approximately 50 percent of the carbon footprint of all perioperative services, and an estimated five percent of a hospital's total GHG emissions (1). Yet not all anesthetic gases are created equal: desflurane has up to 20 times the environmental impact of other anesthetic gases (2). For this reason, the Canadian Anesthesiologists' Society has called for the elimination or restriction of desflurane (among other sustainability actions) in their **2023 Guidelines to the Practice of Anesthesia** (Section 10), and **many hospitals** have already eliminated desflurane use. (3)

The impact of anesthetic gases is measured by assessing their global warming potential over 100 years (GWP100).

- The GWP100 is a relative scale used as a standard comparison of long-lived greenhouse gases, which measures a gas' capacity to trap heat in the atmosphere compared to a similar amount of carbon dioxide (4,5).
- Gases with higher GWP100 trap more heat in the atmosphere over a 100-year time horizon and have a larger contribution to the greenhouse effect and climate change.

Desflurane has a GWP100 of 2540, compared to a GWP100 of 130 for sevoflurane (2,6), and a GWP100 of 265 for nitrous oxide (N_2O). Desflurane persists for 10 years in the atmosphere, compared to 3.6 years for isoflurane and 1.2 years for sevoflurane (7). As such, desflurane is regarded as the most environmentally harmful of the commonly used halogenated anesthetic gases.

To illustrate the impact of these gases in more familiar terms, the emissions released from 1 MAC-hour (1 minimum alveolar concentration-hour), with low or minimal fresh gas flow (FGF) 1 L/min is equivalent to driving 320 kilometres in a car, compared to only 6.5 kilometers for sevoflurane, 14 km for ISO, and 95 km for nitrous oxide* (8).

Note that Nitrous Oxide has additional ozone depleting effects which suggest its use should be limited (9), while propofol poses toxicity risks to aquatic and other environments, and must be disposed of properly (2).

Problem/Opportunity Statement

3 Briefly state the problem you want to solve or the opportunity you want to realize.

Best practice guidelines in Canada and internationally recommend eliminating or minimizing desflurane use because of its high environmental burden. In most Canadian centres, anesthesiologists have a choice of different anesthetic gases, and can use whichever gas is approved and available in their institutions. Individual clinical preferences that may not benefit patient care and have substantial societal costs should not override best practices. It is imperative that "informed anesthesiologists[…]manage choices to safely minimize their carbon footprint"; choosing gases with lower GWP100 values, such as sevoflurane, over those with high values, such as desflurane or nitrous oxide, is a key step in mitigating the environmental impacts of anesthetic practice (9). Moreover, because desflurane is more expensive than the other anesthetic gases, its elimination is accompanied by financial as well as environmental benefits.

Along with its recommendation that the "responsible use of volatile anesthetic agents which are potent greenhouse gases…[includes] choosing agents with the lowest global warming potential and utilizing low total fresh gas flow rates,"* the Canadian Anesthesia Society notes that "environmentally friendlier anesthesia techniques such as neuraxial/regional anesthesia and total intravenous anesthesia may be considered as alternatives to volatile inhalational anesthesia to minimize greenhouse gas burden when clinically appropriate, feasible, and available." (10)

Note that at a recommended FGF of 0.5 L/min, the environmental impact of all gases is significantly reduced (11) (Resources: Action Area 2 Low flow anesthetic gases)

Current State of the System/Process

4 What do things look like today?

1. Prior to a surgical procedure, the anesthesiologist can choose from a variety of anesthetic gases, including Isoflurane, sevoflurane, and desflurane.
2. Anesthetic machines have vaporizers specific to each anesthetic agent.; the anesthesiologist can choose their preference by selecting the appropriate vaporizer.
3. The various volatile anesthetic agents available in clinical practices have subtle pharmacokinetic and pharmacodynamic differences but are largely used to achieve the same aims.
4. If a gas is not present on the machine, it may be stored in multiple locations, including in the pharmaceutical dispensing unit, anesthesia storage room, or in locked cabinets; in such cases, the anesthesiologist can request their preferred gas during surgical set-up.
5. During surgery, the gases are administered using a vaporizer. These vaporizers are often left attached to the anesthetic machine. Alternatively, the anesthesiologist can use intravenous anesthetics, such as propofol, for patient induction and maintenance.
6. Pharmacy monitors the use of anesthetic gases and places orders to replenish supplies through a centralized procurement office.

Root Cause Analysis

5 What gets in your way?

Education & Awareness
- People are unaware of the magnitude of desflurane's environmental impact.
- People are unaware of the clinical viability of alternative anesthetic gases and techniques.

Clinical workflow
- Desflurane was introduced into clinical practice in 1992, prior to sevoflurane. Many anesthesiologists continue to use desflurane out of habit as this is what they use in training and practice.
- Desflurane is effective with few immediate visible drawbacks; it works well for maintenance but is generally not used for inhalational inductions because of its irritant effect on airways.
- Despite the fact that several trials show desflurane has no meaningful advantage for surgical flow or patient safety (**12–17**), there is a lingering perception that:
    - Desflurane has an advantage in ambulatory surgery and bariatrics.
- Patients wake up faster from desflurane, improving surgical flow.

Finances & Procurement
- Reps continue to push desflurane.
- Belief that there may be difficulty procuring enough sevoflurane (supply chain issues).
- At some sites, desflurane was less expensive than sevoflurane until fairly recently.

Note: At North York General Hospital in Ontario, desflurane was less expensive than sevoflurane until around 2020, when the gases reached parity in cost.

Infrastructure
- Perception that emergence will be delayed with the use of agents other than desflurane, potentially slowing flow in the Post Anesthesia Care Unit (PACU) and discharge from day surgery.

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Education & Awareness

- Create a poster showcasing the environmental impact of desflurane relative to other anesthetic gases, and place it in your department. Consult PEACH Ontario's list of Ontario hospitals that have banned desflurane, and communicate to your team that others are ahead in this effort.
- Conduct educational rounds and initiate individual conversations with your team/colleagues to ensure they understand the significant environmental impact of desflurane. Use clinical studies to emphasize that sevoflurane is equally efficacious, cheaper and has a twenty –fold reduced GHG burden compared to desflurane. The following resources can inform your discussions:
    - Environmental Sustainability Guidelines in the Guidelines to the Practice of Anesthesia Revised Edition 2023. (3) **(Resource: Section 10 of Guidelines)**
    - Reducing the carbon footprint of anesthetic gasses, Royal College of Anesthetists. **(Resource: JMT Pierce presentation)**
    - Reducing your contribution to climate change: your choice of anesthetics matters! **(Resource: Sanjiv Mathur presentation)**
    - Limiting the Environmental Impact of Anesthetic Gases. **(Resource: Connor Brenna presentation)**
    - See **references 12–17** for data on clinical safety and patient flow.
- Review the Ontario's Anesthesiologists – Environmental Sustainability Working Group (OA–ESWG) Concierge Service video and share with your team **(Resource: OA–ESWG Concierge Video – Coming soon!)**

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Clinical workflow

- Administer a survey to better understand desflurane use in your OR **(Resource: Anesthetic Gas Survey)**
- Consider adding a GHG component to performance reports by extracting data on usage from your EMR and OR Reports
  - For example, at Mass General Hospital, monthly performance reports were expanded to include two climate assessments: the environmental footprint of the gases chosen, and the flow rate used. (18)
  - Tools such as the Association of Anaesthetists' Anesthetic Gases Calculator and the Yale Gassing Greener app can assist in these calculations
- Undertake a graduated removal of desflurane
  - Medium leverage intervention:
    - Make sevoflurane the default gas on the vaporizer (*Note: this was done at North York General Hospital in Toronto, Ontario*)
      - For example, add warning stickers about carbon intensity placed on desflurane vaporizers (*Note: this was done at Health Sciences North in Sudbury, Ontario, Drs. Mathur and Caycedo as a "medium leverage" intervention* (10)
    - Use low FGF of 0.5 L/min when appropriate to minimize environmental impact of all anesthetic gases (11) ***(Resources: Action Area 2* Low flow anesthetic gases)**
  - High leverage intervention:
    - Remove desflurane from the machine and store desflurane liquid in the Pharmacy or automated medication dispensing system outside the OR.
      - At Health Sciences North in Sudbury, Ontario, the desflurane vaporizer was removed from the anesthesia machine and placed in a designated area outside the ORs. Physicians wishing to use desflurane were required to sign it out from a secure system [PyxisTM], then install the vaporizer themselves (10).
  - Forcing function:
    - Remove desflurane from formulary Note: this has already been done in **many Ontario hospitals**. (19)

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Finances & Procurement

- Create a business case to show potential monetary savings associated with increased use of sevoflurane
  - Note: many hospitals have reported savings;
    - At Health Sciences North in Sudbury, Ontario, the cost savings of total volatile budget was $32,000 (2016 50/50% sevoflurane/desflurane use to 2020 100% sevoflurane). (20)
    - At Providence Health in Oregon, **selecting the lower emission anesthetic reduced costs by 70%.**

Infrastructure

- Designate a locked storage space for desflurane.
- Make necessary changes to anesthetic machine to induce a graduated removal of desflurane described in the "Clinical Workflow" section.

Measure & Test Impact

7 How will you estimate the environmental impact of your changes?

Activity/Outcome Metric

Total number of containers of each type of anesthetic agent used per month

Source(s):
- Pharmacy procurement data

Considerations:
- Obtain purchasing by container for desflurane, isoflurane, sevoflurane, and nitrous oxide.
- Monthly counts are recommended to observe progress, but data can be processed for any given time frame.

*Consult the CASCADES Sustainable Perioperative Care Playbook (11) (**Resource: Action Area 4: Minimal Fresh Gas Flow Anesthesia)** for an alternate measurement strategy based on MAC–hours per gas.

Related Environmental Metric*

Emissions per container in kg CO2e:
Desflurane: 886 kg CO2e (240 ml container)
Isoflurane: 190 kg CO2e (250 ml container)
Sevoflurane: 44 kg CO2e (250 ml container)
Nitrous Oxide: 1054 kg CO2e (size E cylinder 3.4 kg)
Propofol 1 kg (1 million miligrams): 21k g CO2e

Source(s):
- Reducing the carbon footprint of anaesthetic gasses, Royal College of Anaesthetists
- TRA2SH

Considerations:
- Above metrics are based on the following assumed GWP100 for each gas (5):
  - Desflurane: 2540
  - Isoflurane: 510
  - Sevoflurane: 130
  - Nitrous Oxide: 310

ENVIRONMENTAL IMPACT

Considerations:
- Tally the kg CO2e for all gases
- There should be a REDUCTION in this overall number over time
- To translate your results to stakeholders:
  - Use the Natural Resources Canada Greenhouse Gas Equivalencies Calculator
  - Convert amount in kg CO2e to g CO2e then divide by 206 g CO2e (the average emissions per km in Canada [21]) to obtain km driven equivalent (8)
- **Calculations will yield ESTIMATES only**

Embed & Spread

8 What steps have been taken to ensure lasting change? How could it be spread to other contexts?

Micro (What can you do?)

- Conduct Plan–Do–Study–Acts (PDSAs) involving the change ideas presented in section 6.

Meso (What can you do within your organization?)

- Remove desflurane from the formulary
- Department chiefs and hospital administration should directly engage with their anesthesia departments to phase out desflurane as it is a uniquely potent pollutant and burdens pharmacy budgets with unnecessary expense.
- Get involved with hospital procurement contract negotiations for anesthetic gases if possible; work with procurement office to include sustainability as a percentage of pharmaceutical procurement contracts.
- Present to Hospital and/or Finance Board at your hospital

Macro (What can your organization do?)

- Advocacy campaigns could lead to a government ban on the use of desflurane in Canada.
- Lobby pharmaceutical company to stop production/sale of Desflurane.
- Advocate for the reporting of anesthetic gases in provincial hospital greenhouse gas inventories (as in the Ontario Anesthesiologists' position statement to this effect).
- Advocate for carbon pricing on anesthetic gases. (10)
- Spread your success by partnering with other local health systems which have not made change yet by presenting rounds, education talks, etc.

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