

# A Data Driven Approach to Reduction of Greenhouse Gas Emissions

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MassGeneral Brigham

# Disclosures

- No financial disclosures
- I chair Epic's Anesthesia Specialty Steering Board
- I am the MPOG Technical Champion for my health system



## A Story




# **People to Watch 2012: Melissa Everett, Ulster County Executive Director at Sustainable Hudson Valley, Kingston and Rosendale, NY**

Meet Ulster County environmentalist Melissa Everett, one of our people to watch in 2012

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# Part 2: MPOG 2019, Orlando

A composite image featuring an anesthesia machine on the right with a clear vaporizer chamber. The machine has a label that says "ETHER". On the left, a network of glowing blue globes representing Earth is connected by thin lines, resembling a molecular or biological structure. The background is a light, ethereal blue.

**Environmental Impact of Anesthesia**

**Jodi D. Sherman, MD**  
Associate Professor of Anesthesiology,  
and Epidemiology in Environmental Health Sciences  
Yale Schools of Medicine, and Public Health  
[@GreeningDoc](#)

Art A&A 5/12





## SUS-01 : Fresh Gas Flow, less than or equal to 3L/min

### Measure ID

SUS-01

### Domain

Sustainability

### Description

Percentage of cases with mean fresh gas flow (FGF) equal to, or less than 3L/min, during administration of halogenated hydrocarbons and/or nitrous oxide.

### Measure Type

Process

### Threshold

90%

### Rationale

Halogenated agents and nitrous oxide leaking or vented into the atmosphere are environmental pollutants. Reducing fresh gas flows can reduce cost of anesthesia without compromising patient care. This measure considers Fresh Gas Flow (FGF) during administration of halogenated hydrocarbons and/or nitrous oxide, as an indirect measure of anesthetic gas waste.

ow, less than or equal to

ing Footprint,

ing Footprint, Induction

ow, less than or equal to

s Avoided, Induction

esh Gas Flow, Pediatric



## SUS-07: Nitrous Oxide Avoided



# MPOG 2022



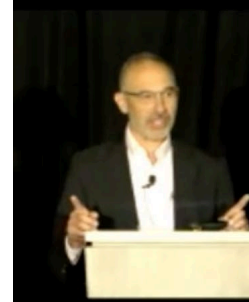
**Intersection of Anesthesia  
and Climate Crisis**

Elizabeth Hansen MD PhD  
Seattle Children's Hospital  
University of Washington



**RESEARCH AND QI PERSPECTIVES ON  
SUSTAINABILITY**





SEEMA GANDHI, MD  
CLINICAL PROFESSOR, DEPARTMENT OF ANESTHESIA AND PERIOPERATIVE CARE  
UNIVERSITY OF CALIFORNIA, SAN FRANCISCO



**LOW-FLOW ANESTHESIA  
EMPOWERING THE CAREGIVER**

Anesthesia Patient Safety Foundation Technology Education Initiative  
In Collaboration with the American Society of Anesthesiologists

Jeffrey M. Feldman, MD, MSE  
Professor of Clinical Anesthesiology  
Children's Hospital of Philadelphia  
Perelman School of Medicine  
University of Pennsylvania  
Philadelphia, PA



# Outline

- Climate and health
- Measuring inhaled anesthetic usage
- Quality measures
- Case study: MGH sustainability efforts



# Multiple organizations have recognized the link between climate change and health

NIH CLIMATE CHANGE AND HEALTH INITIATIVE



## Action Collaborative on Decarbonizing the U.S. Health Sector

NATIONAL ACADEMY OF MEDICINE



Leaders spotlight the critical intersection between health and climate ahead of COP-28 first-ever Health Day  
18 September 2023



Climate and Health

The Impact of Climate Change on Our Health and Health Systems



Climate Change and Health Equity U.S. Department of Health and Human Services



HHS.gov

<https://www.hhs.gov> > about > news > 2023/03/09 > hhs-...

## HHS Reopens Health Sector Climate Pledge



## How Climate Change Affects Human Health





# Climate and Health

- Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter (WHO)
- Climate change affects people's health: (EPA)
  - By changing the **seriousness or frequency** of health problems that people already face.
  - By creating **new or unanticipated** health problems in people or places where they have not been before.
- The U.S. health care sector contributes 8.5% of overall greenhouse gas (GHG) emissions nationally, directly from health care facilities and indirectly through supply chain of goods and services. [Commonwealth Fund]



FEATURED ARTICLES: INFOGRAPHIC

## Global Impact: The Environmental Effects of Anesthetic Drugs

Nathan, Naveen MD

Northwestern University Feinberg School of Medicine (n-nathan@northwestern.edu).

Anesthesia & Analgesia: October 2021 - Volume 133 - Issue 4 - p 825

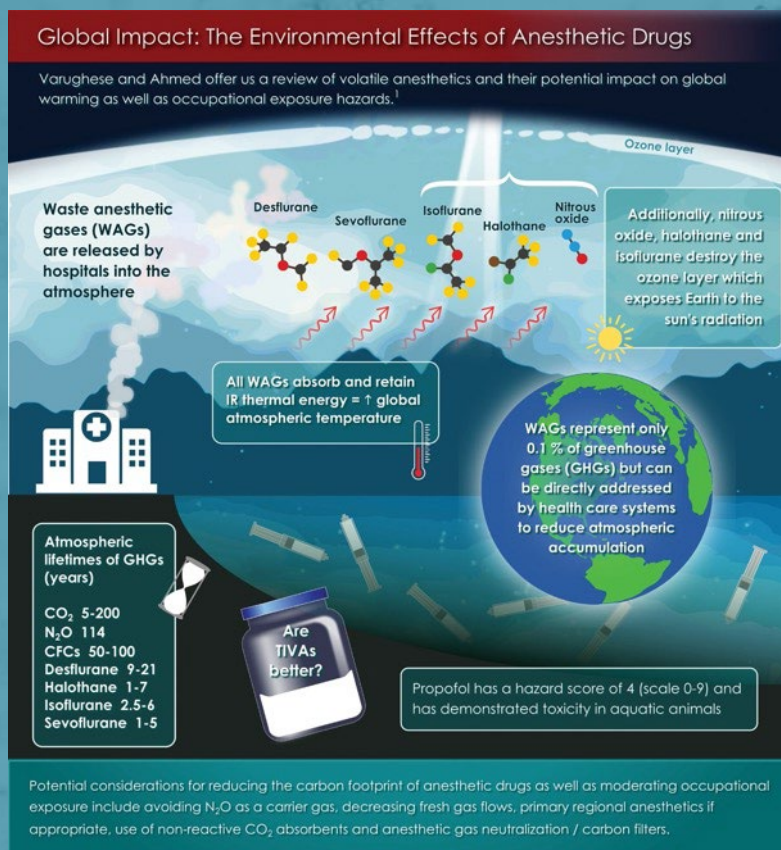
FEATURED ARTICLES: NARRATIVE REVIEW ARTICLE

## Environmental and Occupational Considerations of Anesthesia: A Narrative Review and Update

Varughese, Shane MD; Ahmed, Raza MD

From the Global Medical Affairs, AbbVie Inc, North Chicago, Illinois.

Anesthesia & Analgesia: October 2021 - Volume 133 - Issue 4 - p 826-835



### Simple Perspective

#### Example

- Per hour of anesthesia with fresh gas flow rates of 0.5–2.0 L/min

Gas	Equates with driving <sup>a</sup>
Desflurane	235–470 miles
Isoflurane	20–40 miles
Sevoflurane	18 miles

### Global Perspective

#### Assumptions

- ~200 million anesthetic procedures performed globally each year

#### Climate impact of inhaled anesthetics released

- ~0.01%<sup>b</sup> of CO<sub>2</sub> released from global fossil fuel combustion



# Environmental Impact of Anesthesia Practice

- Waste (disposable equipment, syringes, etc)
- Electricity (equipment, sterilization, suction)
- Water
- IV medication waste (potential toxins)
- Inhaled anesthetics
  - Scavenged waste gas is vented into the atmosphere
  - All anesthetic gases absorb and retain infrared thermal energy
  - Desflurane and nitrous have the highest environmental impact



# Determinants of environmental impact of inhaled anesthetics:

- Fresh gas flow
- Use of nitrous oxide (duration and flow)
- Choice of volatile agent
- Roll-up “currency” =  $\text{KgCO}_2\text{e}$  (“global warming footprint”)
  - Calculated as: mass of agent x GWP





# Inhaled Anesthetics


- Global warming potential (GWP) is a measure of how much the gas contributes to global warming compared to CO<sub>2</sub> (over a specified time)
- Desflurane's impact is primarily due to a very high GWP, while nitrous oxide's deleterious effects come primarily from its long lifespan

Agent	Lifespan	GWP <sub>100</sub> (reference is CO <sub>2</sub> =1)
DESFLURANE	14 yrs	2,540
N <sub>2</sub> O	114 yrs	298
ISOFLURANE	3 yrs	510
SEVOFLURANE	1 yr	130



# Anesthetic gas environmental and financial costs

using GWP100

	Agent	Fresh Gas Flow		kg CO2/hr	 Car MILES driven/hr	8-hr anesthetic day Car MILES driven/day	typical institution costs Cost \$/hr
		FGF					
1	SEVO 1.8% ET	2	L/MIN	2.59 kg	6.3	50 miles	\$5.68
	1-MAC in 40 yr old patient	1	L/MIN	1.3 kg	3.15	25 miles	\$2.84
2	ISO 1.2%	1	L/MIN	2.97 kg	7.2	58 miles	\$1.13
3	N2O 66%	2	L/MIN	60 kg	146	1,168 miles	\$0.90
4	DES 6.6%	1	L/MIN	71.7 kg	174	1,392 miles	\$13.59
	with 1 L/min of O2	2	L/MIN	143 kg	348	2,784 miles	\$27.18



Graphic: Sam Smith, MD, MPH; Harvard Medical School

# Sustainability

The Sustainability Toolkit addresses the selection of anesthetic agents, management of fresh gas flows, and is an overview of the sustainability measures.

## Introduction

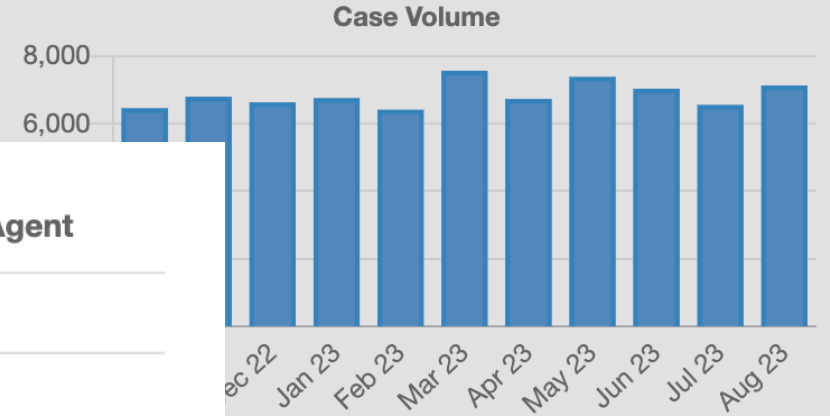
Climate change has become one of the most important public health issues of our time. Anesthesia providers can be part of the solution. As anesthetic agents can be significant environmental pollutants, MPOG has developed a Sustainability Toolkit that provides guidance to reduce our global warming footprint during care of patients undergoing general anesthesia

# MPOG Sustainability Dashboard

## Massachusetts General Hospital: Sustainability

The following measures offer performance data to assess the global warming impact associated with inhalational anesthetic agents.

October 2022 - September 2023

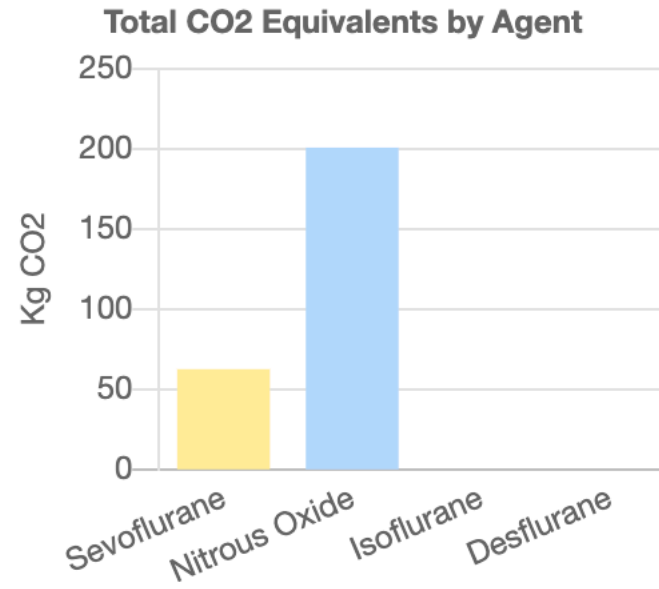


### Carbon Footprint

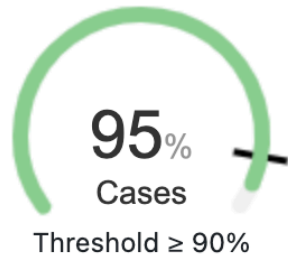
5.04 kg CO<sub>2</sub>/case



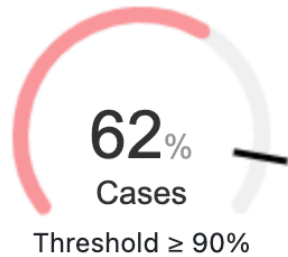
MPOG Average:  
8.97 kg CO<sub>2</sub>/case



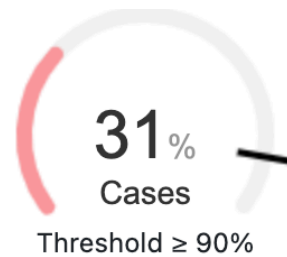
SUS-01  
Fresh Gas Flow,  
less than or equal  
to 3L/min



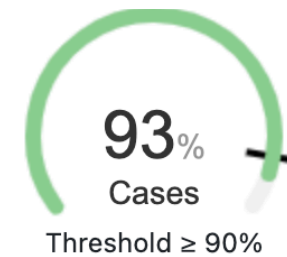
SUS-05-Peds  
Nitrous Avoided,  
Induction



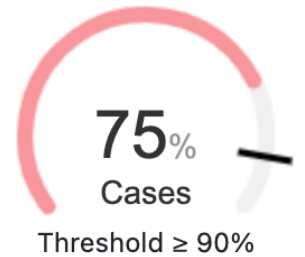
SUS-06-Peds  
Low Fresh Gas  
Flow, Pediatric  
Induction



SUS-07  
Nitrous Oxide  
Avoided



SUS-04  
Fresh Gas Flow,  
less than or equal  
to 2L/min





# MPOG Sustainability Measures

- Fresh Gas Flow
  - SUS-01: FGF  $\leq$  3 LPM
  - SUS-04: FGF  $\leq$  2 LPM
  - SUS-06 (Peds): Low FGF, pediatric induction
- Avoiding Nitrous Oxide
  - SUS-05 (Peds): Nitrous Avoided, Induction
  - SUS-07: Nitrous Oxide Avoided, Maintenance
- Global Warming Footprint (KgCO<sub>2</sub>e)
  - SUS-02: Global Warming Footprint, Maintenance
  - SUS-03: Global Warming Footprint, Induction



## Denominator Considerations (maintenance)

- Includes only cases with an airway AND 30+ min volatile and/or nitrous
- Results will improve from using lower flows or preferable agents
- Switching to TIVA or regional will cause cases to “drop off”



# Pediatric Induction

- Fresh gas flow > minute ventilation does not speed induction, it only produces waste
- Induction can be successfully done without nitrous oxide in many children

Optimal fresh gas flow for induction: ~150 ml/min/kg

<10 kg	2 lpm
10-20 kg	3 lpm
21-30 kg	4 lpm
31-40 kg	5 lpm
>40 kg	6 lpm

Graphics courtesy Ari Weintraub MD, CHOP



# EHR and MPOG - complementary data?

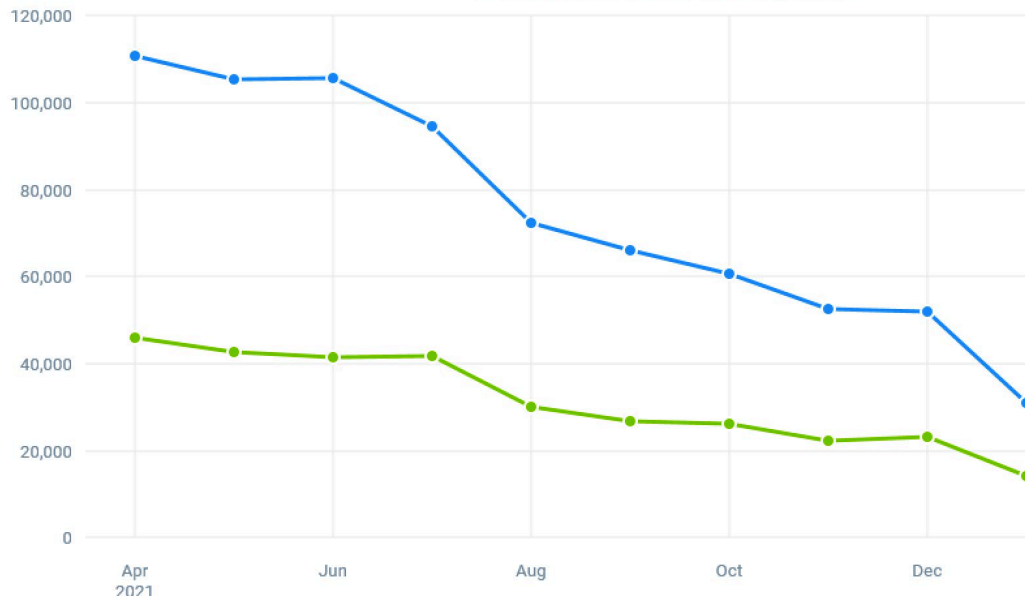
- MPOG advantages
  - Standard/consensus-driven definitions
  - Detailed inclusion/exclusion criteria
  - Ability to benchmark nationally
- EHR data
  - Once set up locally, may be easier to drill down, identify patterns, etc.





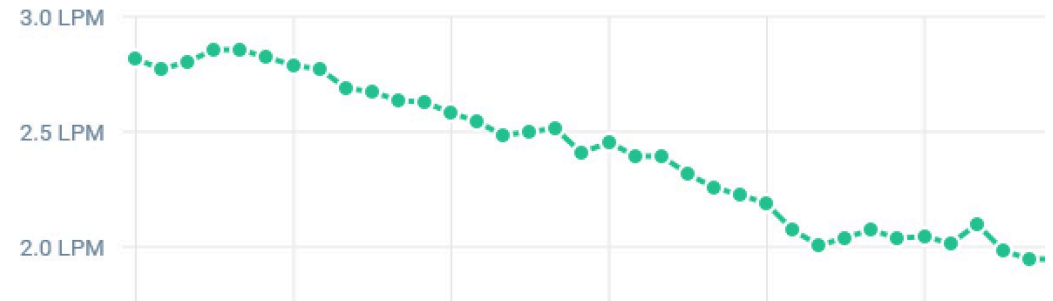
# EHR Reporting - time, gas flows, volume

Total N2O Liters (blue) and Minutes (green)  
Between 4/1/2021 and 3/31/2022 by month



Av FGF (LPM, cases with LMA or ET...)

Between 10/1/2020 and 9/30/2023 by month



Total Sevoflurane Minutes

1,738,694 minutes

Total Isoflurane Minutes

200,633 minutes

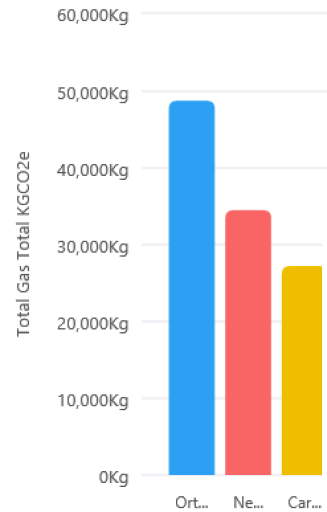
Total Desflurane Minutes

1,327 minutes

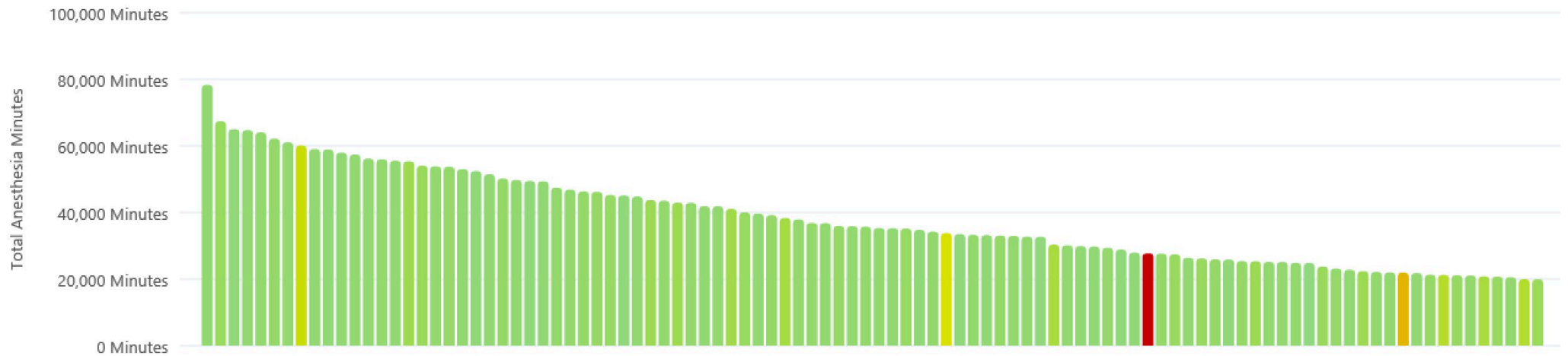


# Drill down examples - service and provider

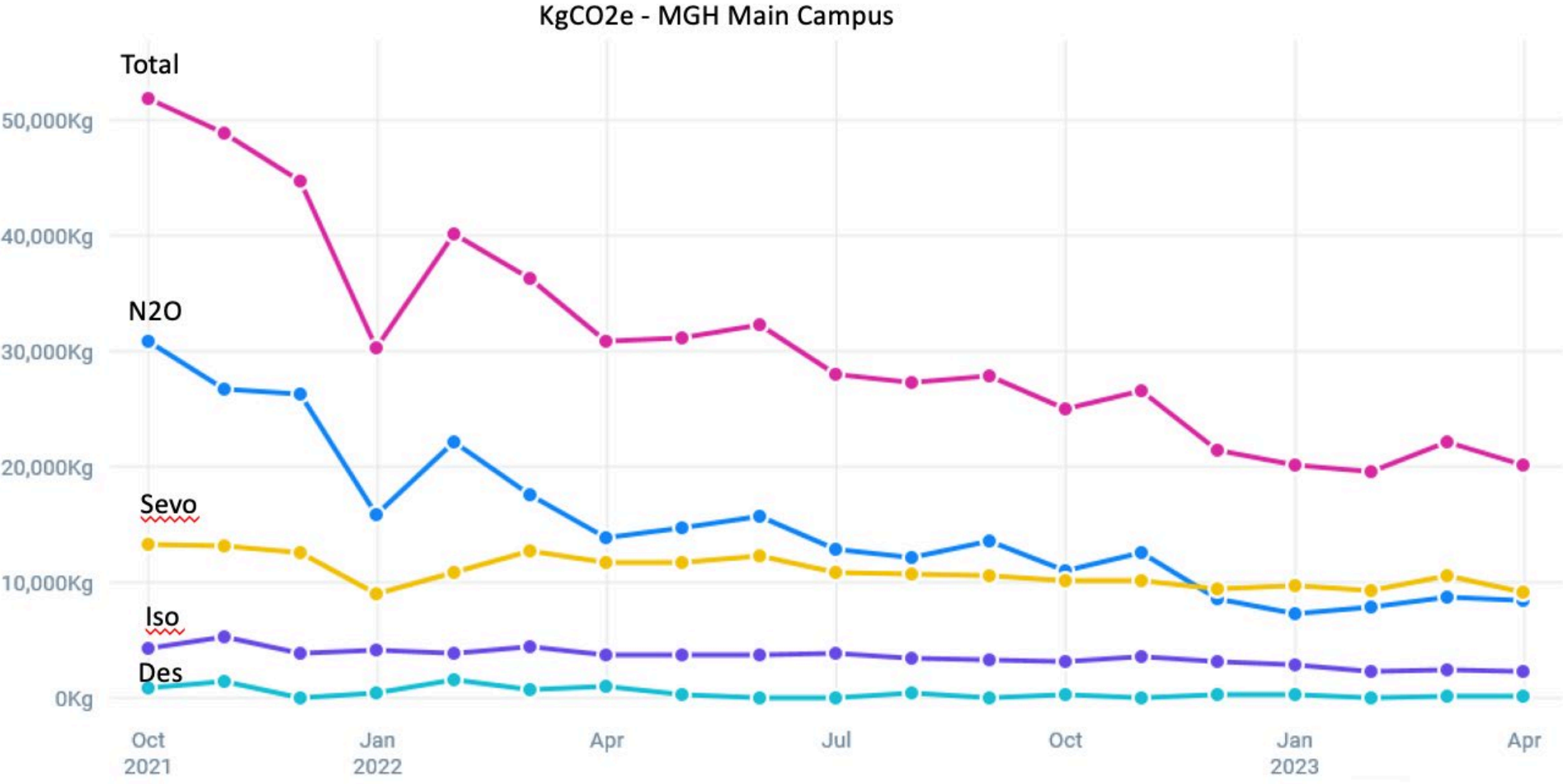
Total Gas KgCO2e by Service



KgCO2e/hr by Provider



# MGH Anesthesia



# MGH Anesthesia - Sustainability

- Annualized KgCO<sub>2</sub>e now 25% of baseline from 2021
- Sevoflurane consumption down by 40% (from lower FGF)
- Estimated cost savings \$115,000/year
  
- KgCO<sub>2</sub> decrease from all gases, using EPA calculator:



789,600  of Carbon Dioxide (CO<sub>2</sub>) equivalent

This is equivalent to greenhouse gas emissions from:

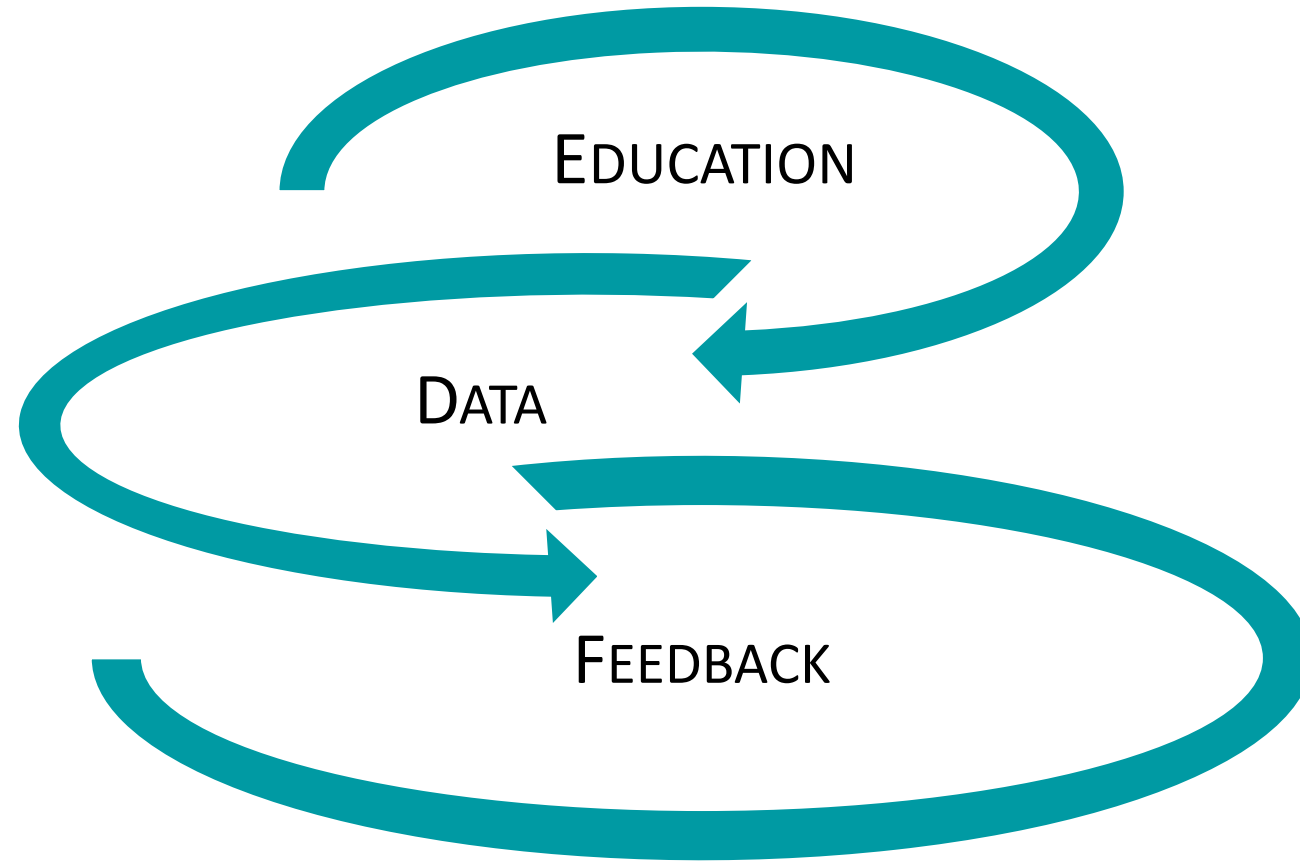
**176** gasoline-powered passenger vehicles driven  
for one year 



**2,024,178** miles driven by an average gasoline-  
powered passenger vehicle 



# QI Initiative: Sustainability





# MGH Sustainability Interventions

11/21: Added FGF<3L metric to MPOG provider emails

- 2/22: 2 hour Grand Rounds- Sustainability Conference

3/22: Began developing EHR reports to assess total impact and service/provider variation

- 5/22: Changed MPOG FGF metric to 2L threshold

6/22: Turned on EHR BPA for high FGF

- 10/22: Posted FGF for pediatric inductions

11/22 Added SUS-02 (Global Warming, maintenance)

- 3/23: Grand Rounds on Low Flow, Educational Modules
- 5/23: Published EHR sustainability dashboard



# QI/Change Management - Lessons Learned

- Trust but verify
- Build your case for change
- Listen to concerns
- Stress that safety & optimal care are always most important
- Look for quick wins, celebrate progress
- Incentives work
- Beware unintended consequences



# Questions/Discussion

