Sustainability Workgroup

May 12, 2025
1:00pm - 2:00pm Eastern Time

MPOG
MULTICENTER PERIOPERATIVE OUTCOMES GROUP

Agenda

Introductions and goals for the meeting

Measures discussed at April meeting:

- SUS-01: Fresh Gas Flow, less than or equal to 3 L/min
- SUS-04: Fresh Gas Flow, less than or equal to 2 L/min
- SUS-02: Global Warming Footprint, Maintenance
- SUS-05-Peds: Nitrous Avoided, Induction

Measures to discuss:

SUS-03: Global Warming Footprint, Induction
SUS-06-Peds: Low Fresh Gas Flow, Pediatric Induction
SUS-07: Nitrous Oxide Avoided

Modify measures

- Identify areas identified by the coordinating center to modify measures
- Identify opportunities identified by workgroup to modify measures

Review Literature Updates

Summary and next steps

MPOG

Sustainability Workgroup Members

Name	Institution
Brady Still, MD	UChicago
Seema Gandhi, MD	UCSF
Ben Stam, MD	Corewell West & UM West
Eva Lu Boettcher, MD	University of Wisconsin
Katie O'Conor, MD, MBA	Johns Hopkins
Nick Dalesio, MD	Johns Hopkins
Lucy Everett, MD	Mass General
Liz Hansen, MD	Seattle Children's
Jonathan Paul, D.O.	Columbia University
Jodi Sherman, MD	Yale
Anjan Saha, MD, PhD	Columbia University

Summary from April meeting

Meeting on April 28th

SUS-01 and SUS-04

- Group generally supported a low flow measure (.i.e. Flow < 1 L/min), should be accompanied by a low carbon footprint measure (update to SUS-02). Consider retiring SUS-01
- Group generally agreed that we should remove exclusion for < 30 minutes so that we can encourage lower flows for short cases

SUS-02

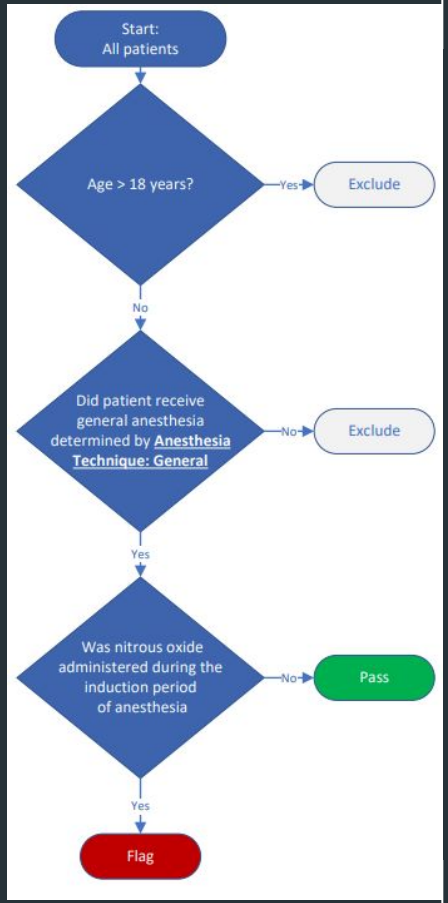
- Cuveele method - more accurate but may limit participation to fewer sites. The coordinating center will explore whether more sites can submit MV and end tidal agent concentration data
- Change GWP value from GWP100 to GWP20, as it won't significantly affect relative performance trend over time, nor alter recommendations regarding the choice of anesthetic agents or administered flow
- The group agreed on the need for a more detailed analysis of shorter cases - those less than hour - by comparing them against the per-minute, rather than the per-hour, kg CO_2 equivalents of 2% sevoflurane at 2 L/min

Meeting on April 28th

SUS-05-Peds

- The group is considering excluding standard IV inductions given to minimize score inflation (nitrous oxide is less likely to be used during induction for IV inductions)

SUS-05 Result	Induction Type			
	Intramuscular	IV Induction	Mask Induction	Rapid Sequence Induction
Failed	6.25%	8.99%	39.67%	9.68%
Passed	93.75%	91.01%	60.33%	90.32%



IV Induction - SUS-05 Flagged

Age	Induction_Type	Induction_Start	Induction_End
13	Rapid Sequence I	3/25/2025 7:58	3/25/2025 8:15

	Induction Procedure	Intravenous
	Airway - Freetext Comments	RSI given patient emesis just prior to induction
	Mar 25, 2025 (day of surgery)	
07:54	Patient in Room	Patient in OR $$
07:59	ROCURONIUM	60 mg
07:59	PROPOFOL	200000 mcg
07:59	Induction Start	Induction
08:00	Nitrous Insp %	59.2
08:01	Flows Nitrous Oxide (L/min)	5.6
08:01	Nitrous Insp %	64.8
08:02	Flows Nitrous Oxide (L/min)	5.6
08:02	Nitrous Insp %	68.7
08:03	Flows Nitrous Oxide (L/min)	5.6
08:03	Nitrous Insp %	68.8
08:04	Flows Nitrous Oxide (L/min)	5.6
08:04	Nitrous Insp %	69
08:05	Nitrous Insp %	69.1
08:05	Flows Nitrous Oxide (L/min)	5.6
08:06	Flows Nitrous Oxide (L/min)	5.6
08:06	Nitrous Insp %	68.9

Age	Induction_Type	Induction_Start	Induction_End
6	IV Induction	3/22/25 19:50	3/22/25 19:59

	Assessment and Plan - Comments	IV induction
	Mar 22, 2025 (day of surgery)	
19:45	Patient in Room	Patient In - OR
19:46	MIDAZOLAM	1 mg
19:50	Induction Start	G/A Induction
19:51	Nitrous Insp %	36
19:52	Nitrous Insp %	67
19:53	Nitrous Insp %	65
19:54	Nitrous Insp %	14
19:55	Nitrous Insp %	6
19:56	PROPOFOL	50 mg
19:56	Nitrous Insp %	2
19:57	Nitrous Insp %	1
20:05	Anesthesia Ready	Anesth Ready

Proposed update?

- Create additional induction type value “IV with volatile agent” (combo).
- If Combo, then include in SUS-05.
- If IV induction or RSI alone, then exclude?

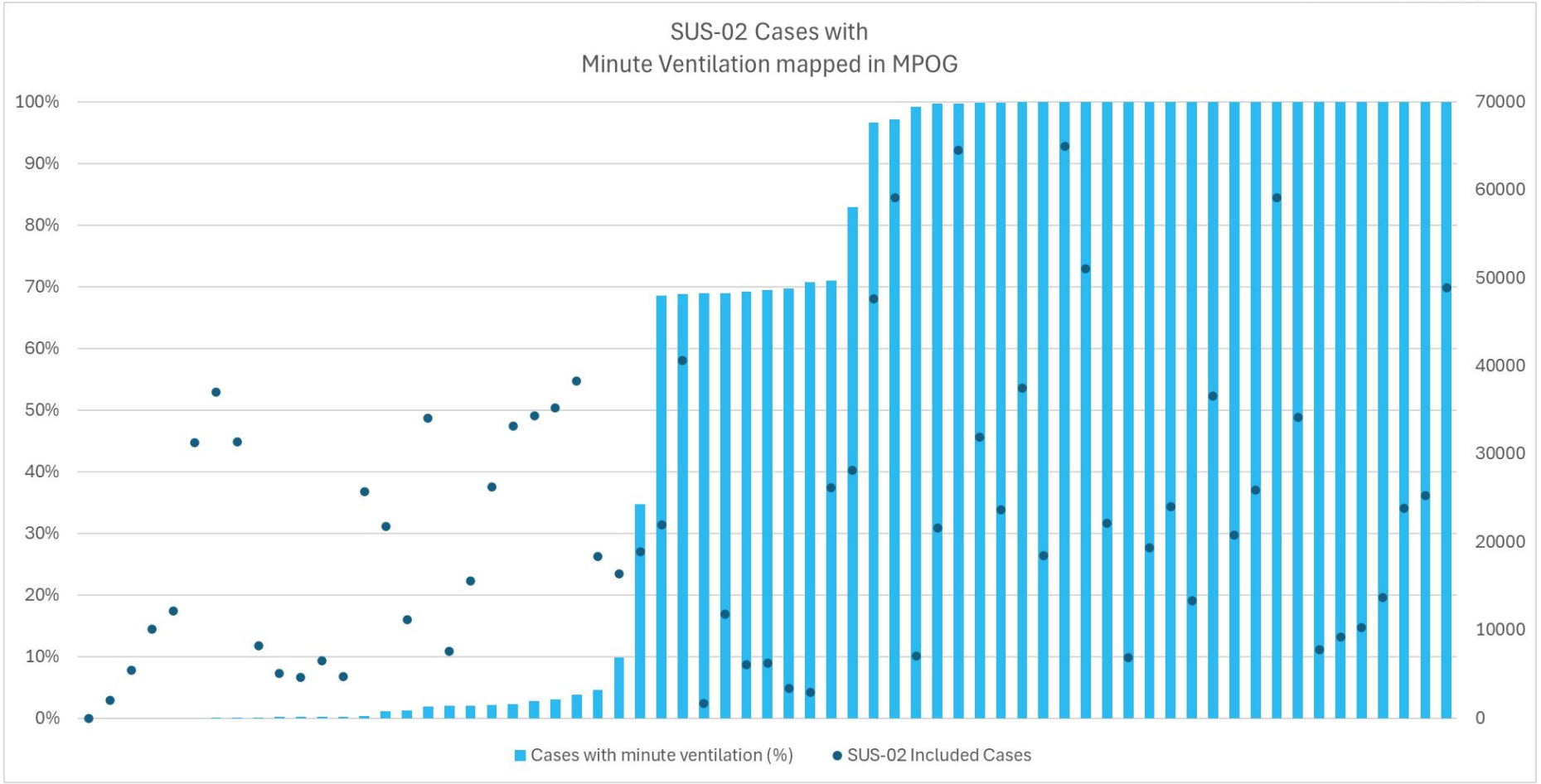
Cuveele query results for SUS-02

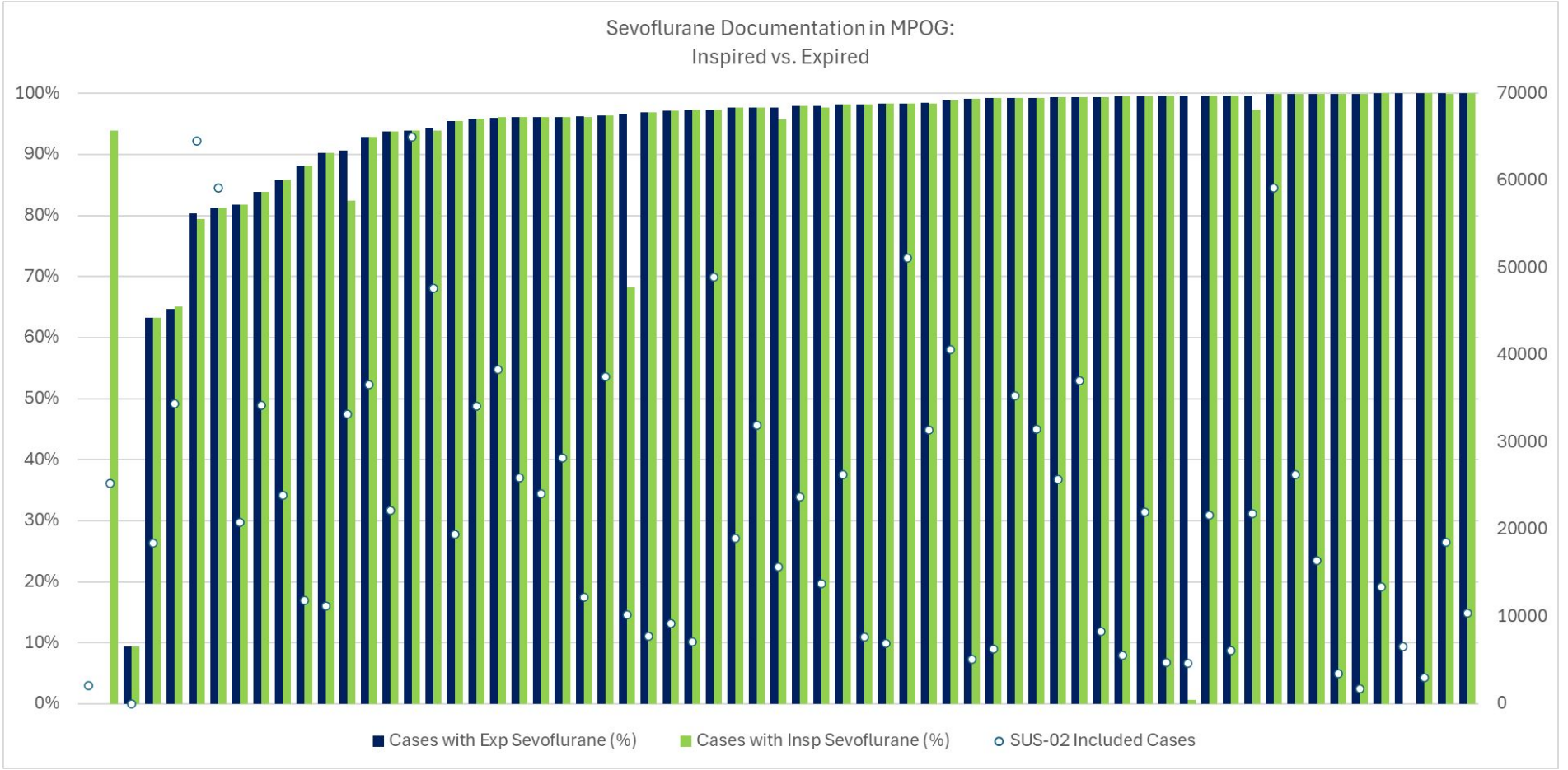
Cuveele's method to calculate anesthetic agent

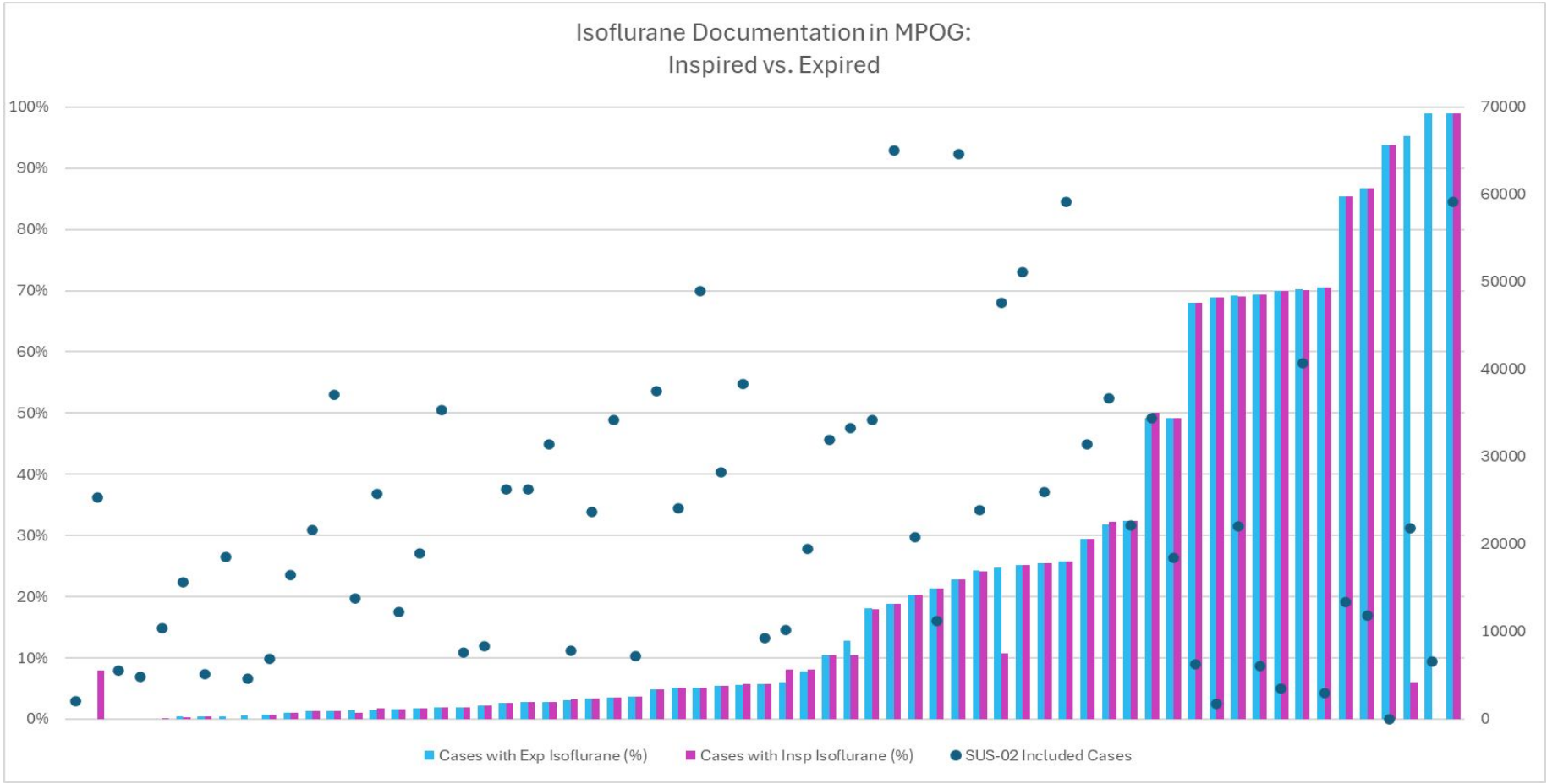
- If both fresh gas flow (FGF) and vaporizer dial setting (dialed F_{VAP}) are available, anesthetic agent consumption can be calculated as a product of FGF and F_{VAP}
- If F_{VAP} is unknown, theoretical model for calculating F_{VAP}, based on FGF, minute ventilation (MV), agent inspired concentration (F_{IN}), agent end-expired concentration (F_{ET}) and dead space ventilation (V_D)
- $F_{VAP} = [F_{IN} - (\text{dead space fraction} * F_{IN} + (1 - \text{dead space fraction}) * F_{ET}) * (1 - FGF/MV)]/(1-(1 - FGF/MV))$
- Dead space fraction for sevoflurane, desflurane, and isoflurane was determined empirically by Cuveele et al

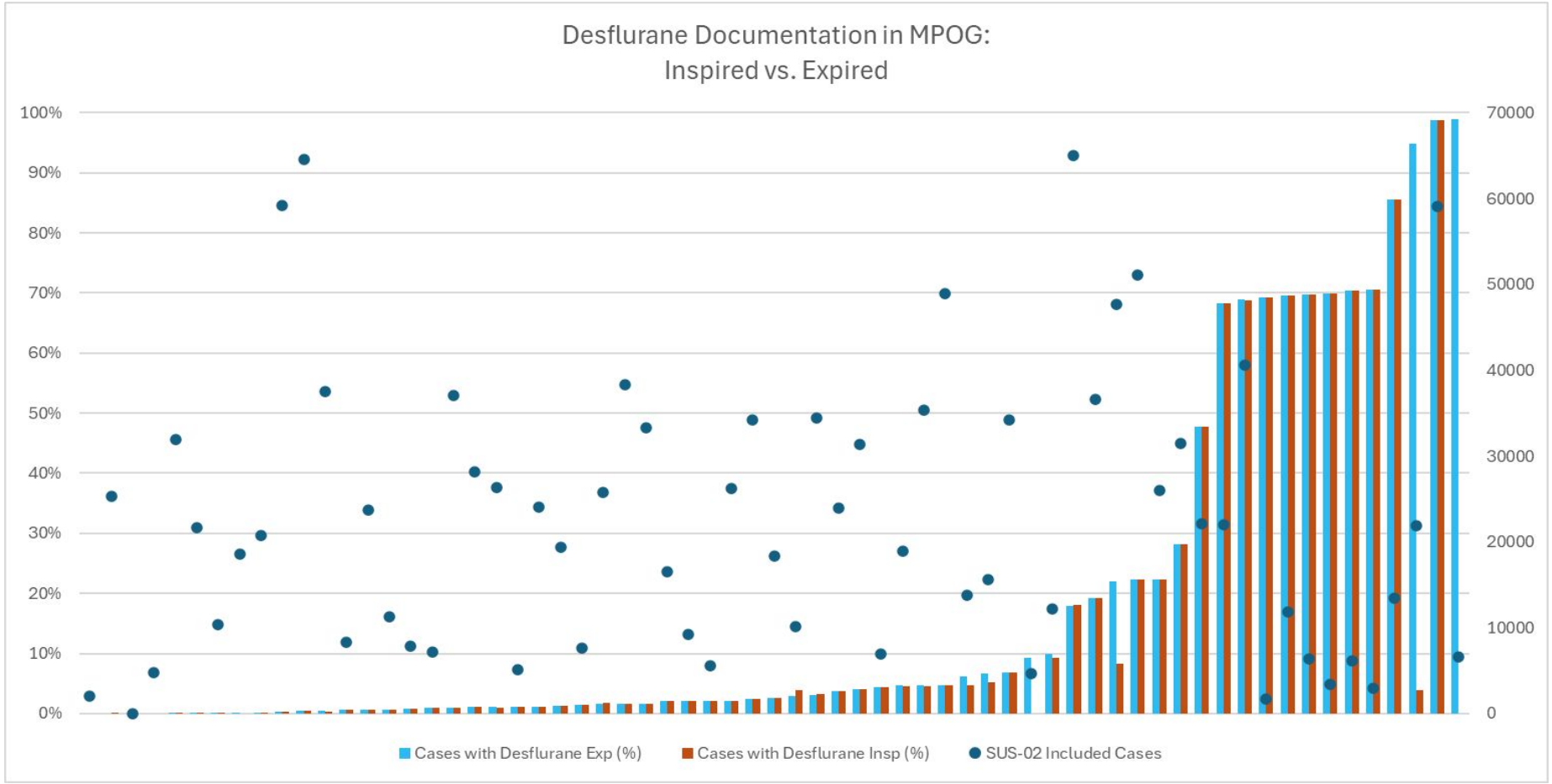
$$F_{VAP} = \frac{F_{IN} - (\text{dead space fraction} * F_{IN} + (1 - \text{dead space fraction}) * F_{ET}) * \text{fraction of rebreathing}}{(1 - \text{fraction of rebreathing})}$$

$$\text{Amount of vaporized agent (L/min)} = \frac{FGF * (F_{IN} - (\text{dead space fraction} * F_{IN} + (1 - \text{dead space fraction}) * F_{ET}) * \text{fraction of rebreathing})}{(1 - \text{fraction of rebreathing})}$$


SUS-02 Cases with
Minute Ventilation mapped in MPOG
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
70000
60000
50000
40000
30000
20000
10000
0
Cases with minute ventilation (%)
SUS-02 Included Cases


Sevoflurane Documentation in MPOG:
Inspired vs. Expired
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
70000
60000
50000
40000
30000
20000
10000
0
Cases with Exp Sevoflurane (%)
Cases with Insp Sevoflurane (%)
SUS-02 Included Cases


Isoflurane Documentation in MPOG:
Inspired vs. Expired
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
70000
60000
50000
40000
30000
20000
10000
0
Cases with Exp Isoflurane (%)
Cases with Insp Isoflurane (%)
SUS-02 Included Cases


Desflurane Documentation in MPOG:
Inspired vs. Expired
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
70000
60000
50000
40000
30000
20000
10000
0
Cases with Desflurane Exp (%)
Cases with Desflurane Insp (%)
SUS-02 Included Cases

SUS-02: Inspired/Expired agent and Minute Ventilation Fill rates (%)

	Sevoflurane	Isoflurane	Desflurane
% Inspired documented	92.5%	20.9%	14.6%
% Expired documented	92.1%	23.0%	16.9%

Minute Ventilation
64.3%

Measure Review: SUS-03

SUS-03: Global Warming Footprint, Induction

Description: Total carbon dioxide equivalents per induction for cases where halogenated agents and/or nitrous oxide was administered during the induction period of anesthesia.

Threshold: Not applicable - informational only

Exclusions:

- Cases in which halogenated hydrocarbons or nitrous oxide are NOT used for induction
- Cases with only manually documented fresh gas flow values (fresh gas flow values must be automated to be considered for this measure)

Success: Carbon dioxide equivalents will be reported as kilograms of CO_2 equivalents per case. A CO_2 limit of 50 kg CO_2 has been set for this informational measure to ensure that all cases ‘pass’ since a threshold has not yet be established in the literature.

- Emissions data are also converted to other meaningful equivalencies & reported as:
  - Miles driven by an average gasoline-powered passenger vehicle
  - Gallons of gasoline consumed

SUS-03: Global Warming Footprint, Induction

Miles driven by an average gasoline-powered passenger vehicle (per EPA.gov)

- Convert kg CO_2 equivalents to metric tons: Total CO2 / 1000
- Convert metric tons CO_2 to miles driven: Metric tons CO2 eq / (0.000403)

Gallons of gasoline (per EPA.gov)

- Convert kg CO_2 equivalents to grams of CO2 equivalents: Total kg CO2 * 1000
- Convert grams CO2 eq to gallons of gasoline: Grams CO2 eq / 8,887

SUS-03: Global Warming Footprint, Induction

Other Measure Details:

- Inhalational agents and flows will be assessed and considered as artifact if inside the ranges listed within the Halogenated Anesthetic Gases and Nitrous Oxide Used phenotypes
- If Fresh Gas Flow Total (Concept ID:3214) is documented for the case, this concept will be used to determine success of halogenated agents or nitrous oxide use
- If Fresh Gas Flow Total (Concept ID:3214) is **not** documented for the case, MPOG will calculate Fresh Gas Flow: Flows Oxygen (ID:3215) + Flows Air (ID:3220) + Flows Nitrous Oxide (ID:3225)

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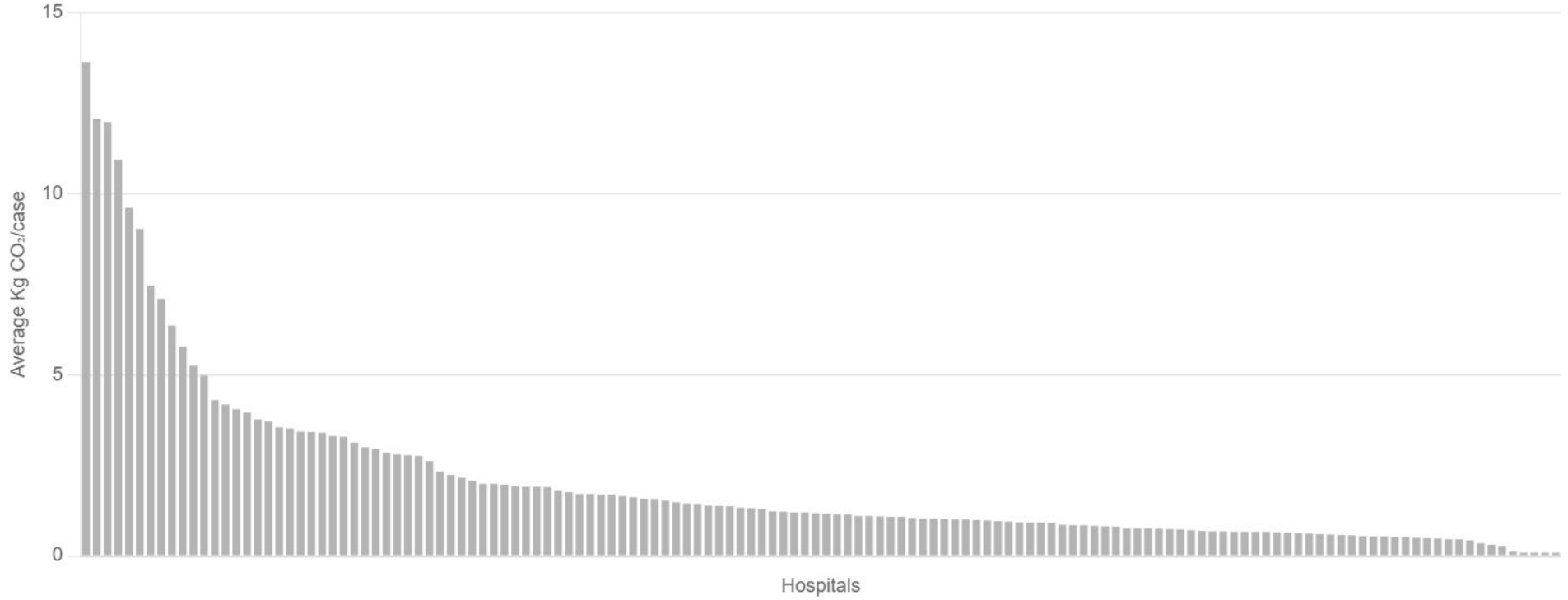
SUS-03 - All MPOG Institutions, May 2024 - March 2025



Mean kg CO2 during induction (0.04 - 13.64)

Measure Review: SUS-06-Peds

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

Description: Percentage of pediatric cases < 18 years old with a mean fresh gas flow (FGF) equal to or less than a weight-based threshold during the induction phase of anesthesia.

Threshold: 90%

Exclusions:

- Age ≥ 18 years
- Cases without a valid weight documented
- Cases without fresh gas flow data documented during induction
- Cases in which halogenated hydrocarbons or nitrous oxide are not used during induction

Success Criteria: Mean FGF equal to, or less than the weight-based max FGF (L/min) during the induction period of anesthesia

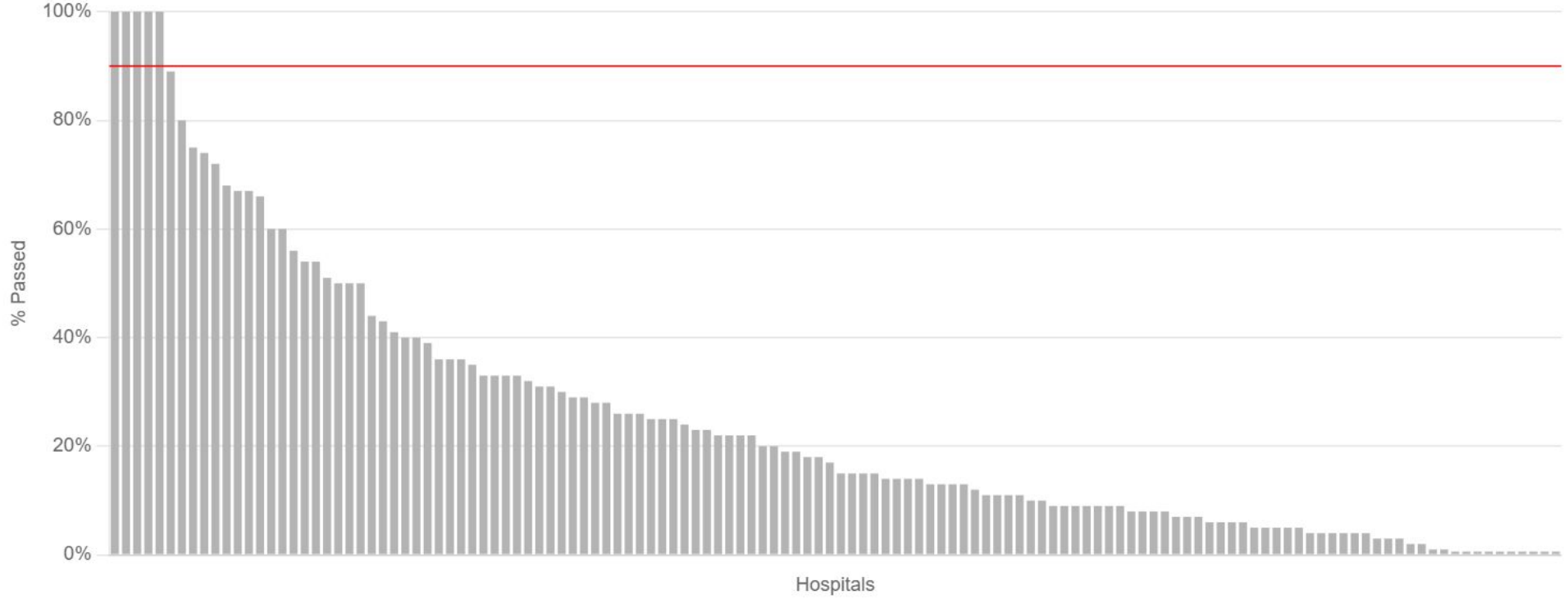
SUS-06-Peds: Low Fresh Gas Flow, Pediatric Induction

Other Measure Details:

- If Fresh Gas Flow Total (Concept ID:3214) is documented for the case, this concept will be used to determine success of halogenated agents or nitrous oxide use
- If Fresh Gas Flow Total (Concept ID:3214) is not documented for the case, MPOG will calculate Fresh Gas Flow: Flows Oxygen (ID:3215) + Flows Air (ID:3220) + Flows Nitrous Oxide (ID:3225)
- Weight based thresholds:

Weight (kg)	Mean FGF
< 20	≤ 3 L/min
20 - 30	≤ 4 L/min
30 - 40	≤ 5 L/min
> 40	≤ 6 L/min

Current SUS-06-Peds Performance, All MPOG Institutions, May 2024 - March 2025



Performance: 0% - 100%

Measure Review: SUS-07

SUS-07: Nitrous Oxide Avoided

Description: Percentage of adult cases where nitrous oxide is avoided during anesthesia.

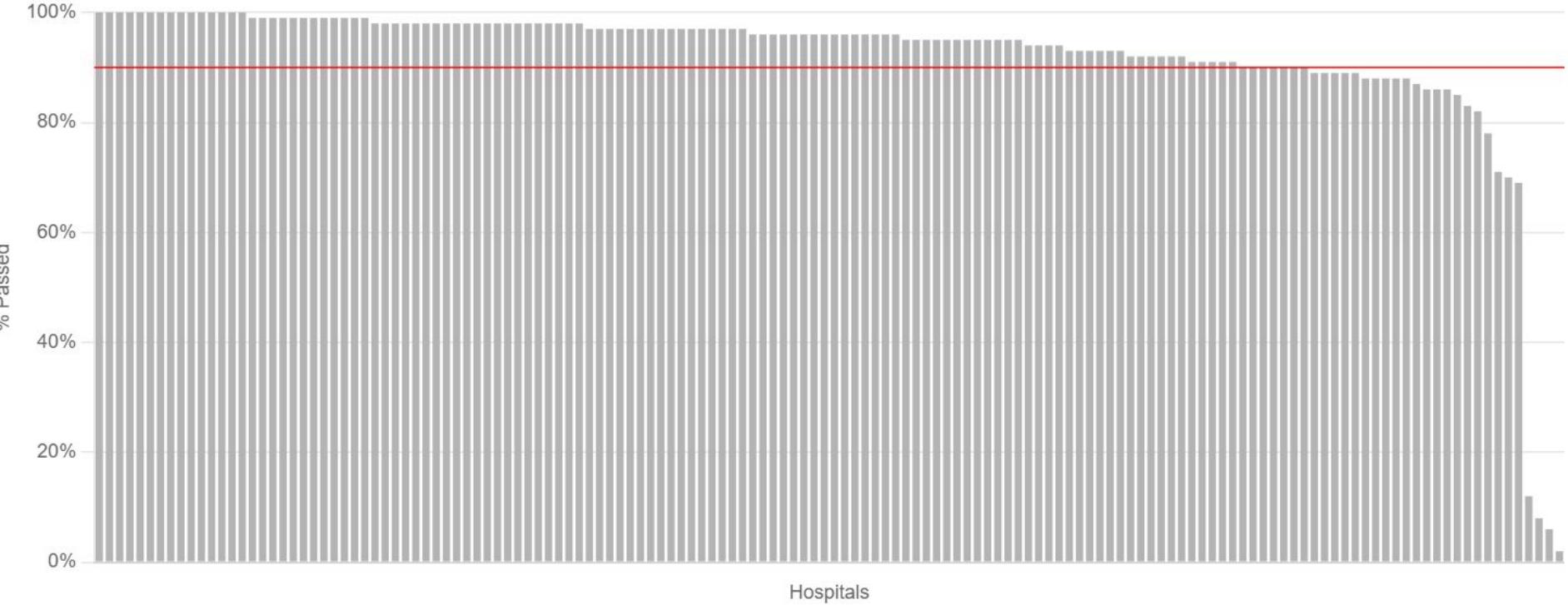
Threshold: 90%

Exclusions:

- Age < 18 years

Success: Nitrous oxide was not administered during Anesthesia Start to Anesthesia End

Current SUS-07 Performance, All MPOG Institutions, May 2024 - March 2025



Recent updates to literature

Publications

- Beard JW et al., 2025 Environmental and economic impacts of end-tidal control of volatile anesthetics
- Beard JW et al., 2024 Anesthesia delivery via manual control versus end-tidal control
- Cuveele L et al., 2023: Development of validation of a model to calculate anesthetic agent consumption
- Olmos A et al., 2023: Reducing volatile anesthetic waste using a commercial EHR CDS tool to lower FGF
- ASA Committee on Equipment and Facilities, 2023: Statement on the use of low gas flows for sevoflurane
- Sondekoppam RV et al., 2020: The impact of sevoflurane anesthesia on postoperative renal function
- Kennedy RR et al., 2019: There are no dragons: Low-flow anesthesia with sevoflurane is safe
- Brioni JD et al., 2017: A clinical review of inhalational anesthesia with sevoflurane
- Sherman J et al., 2012: Life cycle greenhouse gas emissions of anesthetic drugs

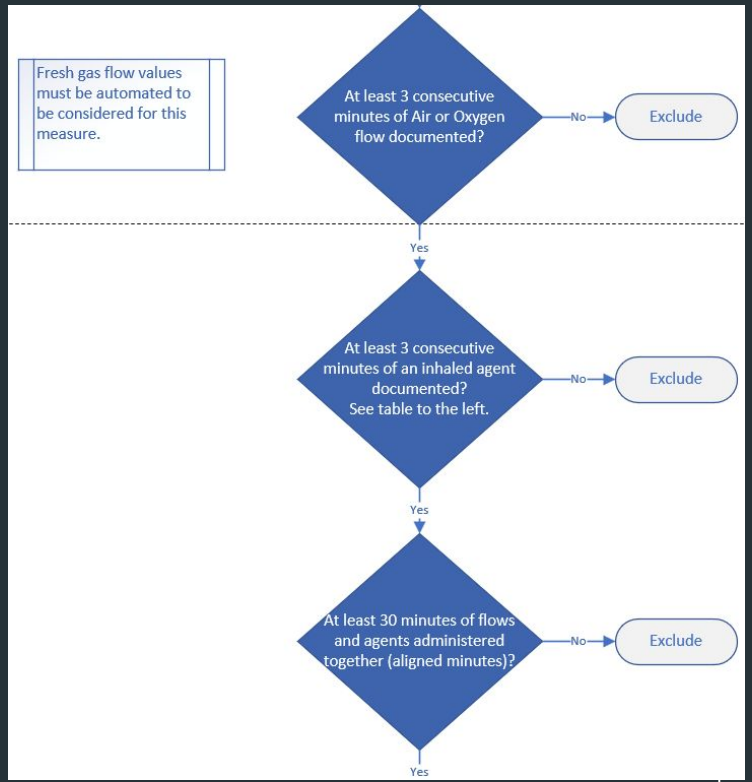
Upcoming changes

Update exclusion logic for SUS-01 and SUS-04

- SUS-01 and SUS-04 calculate mean FGF for the measure based on overlapping time of inhaled anesthetic agents and fresh gas flow. Example: if there are 30 cumulative minutes halogenated, but only 24 minutes of fresh gas flow, the mean FGF is then calculated using the 24 minutes of overlapping time
- Currently, measures exclude cases with < 30 minutes of inhaled anesthetic agents administered between intubation and extubation
- Future state: cases with < 30 minutes of overlapping inhaled anesthesia agents AND fresh gas flow will be excluded
- Should we just remove the 30 minute exclusion and include all cases regardless of duration between intubation and extubation?

Automated FGF logic added to SUS-01 & SUS-04

- The code will first verify documentation of Air and Oxygen flows for 3 consecutive minutes (i.e. concepts 0730, 0731, 0732),
- Next, it checks whether there are at least 3 consecutive minutes during which agents (sevo, des, iso, or nitrous) are being administered
- Following that, it analyzes whether there are at least 30 minutes in which both agents and flows are administered
- If the code returns ‘No’ for any of these checks, the case is excluded. If a ‘Yes’ is returned, the case is included and the FGF value is calculated



Artifact thresholds for inhaled agents

- Low and high artifact thresholds for inhaled anesthetic agents (% or flow) references the Inhalational Anesthetic Duration phenotype

MPOG Concept ID	Concept Name	Lowest Threshold of Clincal Significance (%)	Highest Threshold of Clincal Significance (%)
3225	Flows Nitrous Oxide (L/min)	0.2	20
3250	Nitrous Insp %	20	80
3255	Nitrous Exp %	20	80
3260	Isoflurane Exp %	0.3	10
3265	Isoflurane Insp %	0.3	10
3270	Sevoflurane Exp %	0.4	10
3275	Sevoflurane Insp %	0.4	10
3280	Desflurane Exp %	1.2	20
3285	Desflurane Insp %	1.2	20
3290	Halothane Exp %	0.5	10
3295	Halothane Insp %	0.5	10
3297	Enflurane Exp %	0.5	10
3298	Enflurane Insp %	0.5	10
3299	Miscellaneous Volatile Agent Insp %	0.3	20
3300	Miscellaneous Volatile Agent Exp %	0.3	20

Thank You!