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Reducing Greenhouse Gas Emissions in Jackson

A CQI Story about the Triumphs of Science and Collaboration in Changing Clinical Operations

Co-Authors

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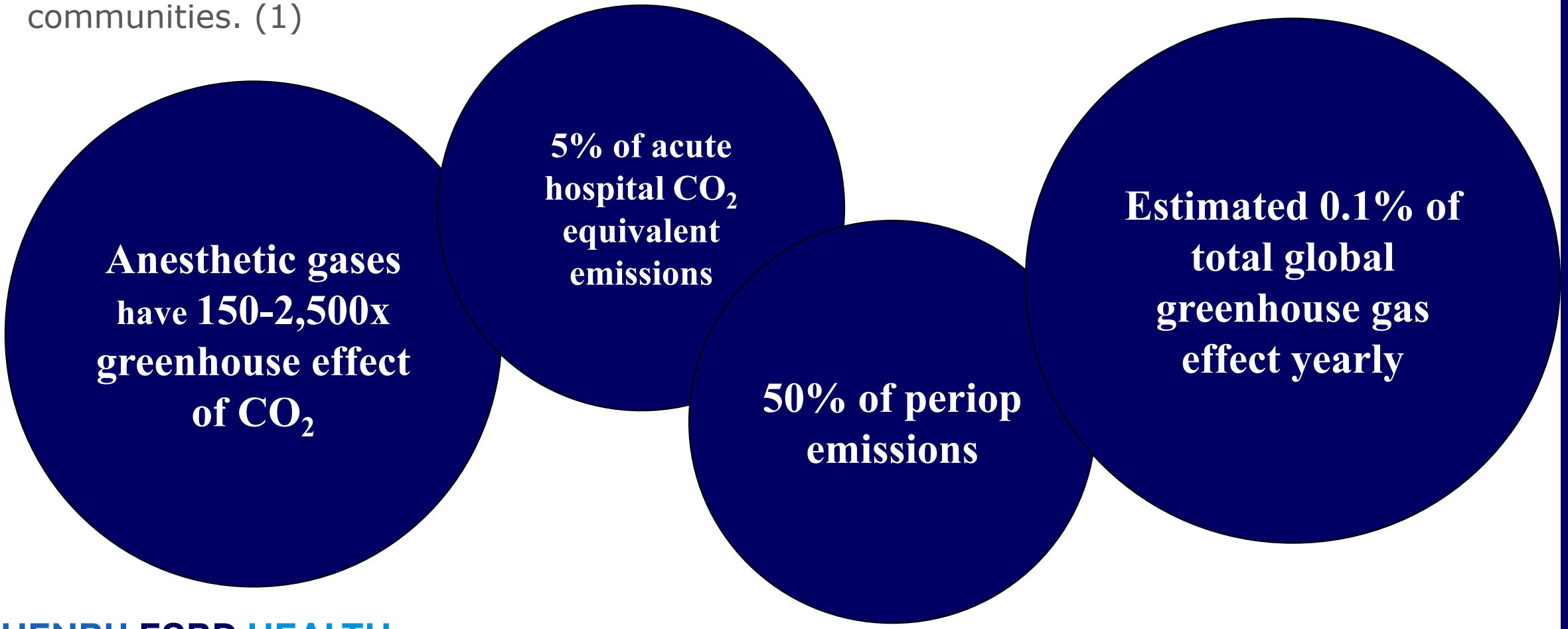
Background

- The climate change crisis threatens human health by adversely affecting the spread of infectious disease, malnutrition, mental health, and the displacement of people or communities. (1)



Aims

Reduce greenhouse gas emission from anesthetic gas waste

- **MPOG goal:** at least 45% of cases in 2024 will have an average hourly emissions profile of 2.83kg CO_2 equivalents per hour of maintenance anesthesia.
- **HFHS Jackson goal:** reduce average hourly emissions rate each month by 40% by February 2024 and maintain that level into the future.

Measures

SUS-01 – Fresh Gas Flow only

- Percentage of cases using inhaled anesthetics with mean fresh gas flow during maintenance ≤ 3L/min
- Target for P4P ≥95% of cases

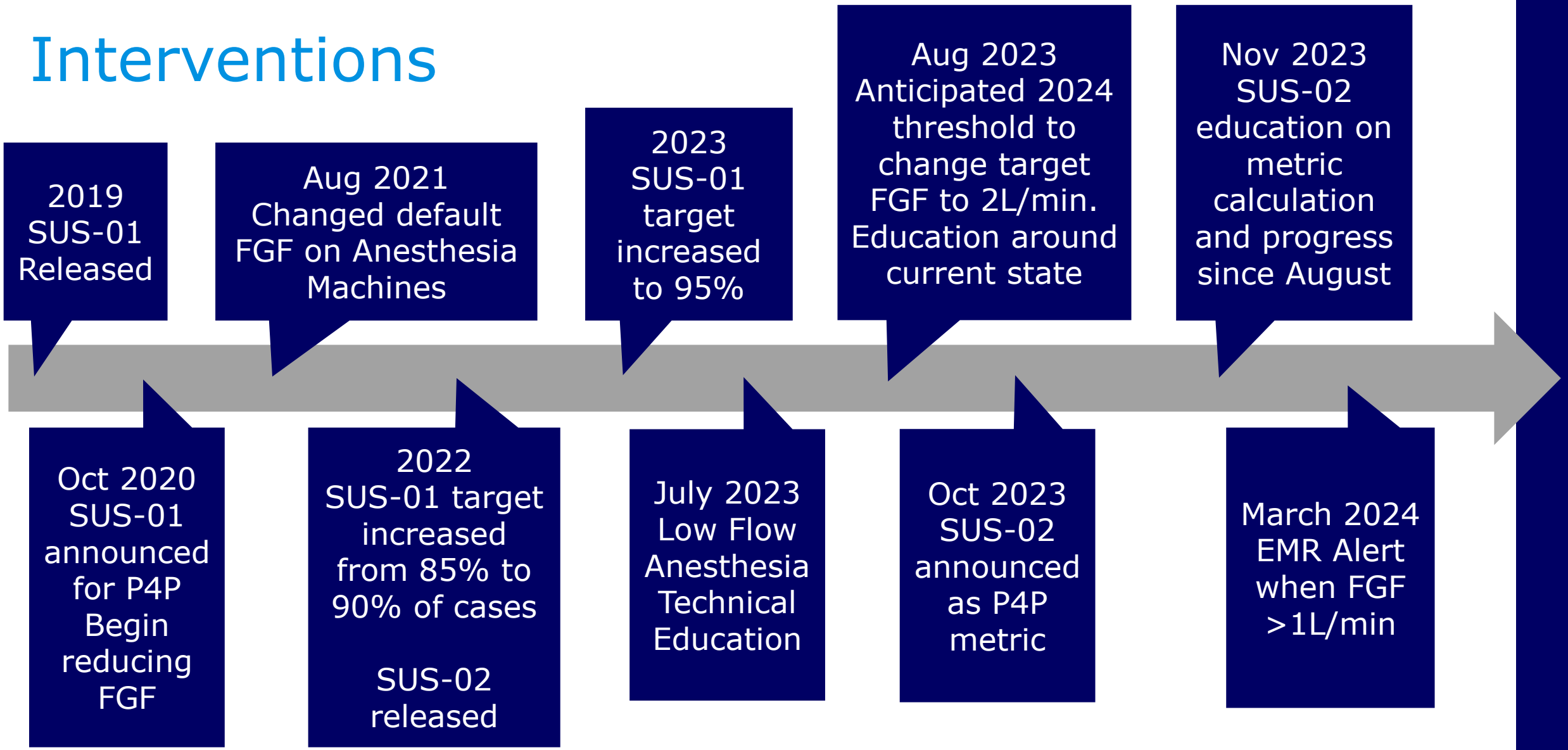
SUS-02 - Anesthetic gas converted to CO_2 equivalent based on greenhouse gas effect

- Metric is calculated based on percentage of cases with either:
  - Average emissions below a threshold of 2.83kg CO_2eq/hr
  - Total maintenance emissions below 2.83kg CO_2eq
- Calculation based on GWP^{100}
- Threshold set based on moderate usage of least toxic agent, sevoflurane, 2% at 2L/min
- Target for P4P ≥45% of cases

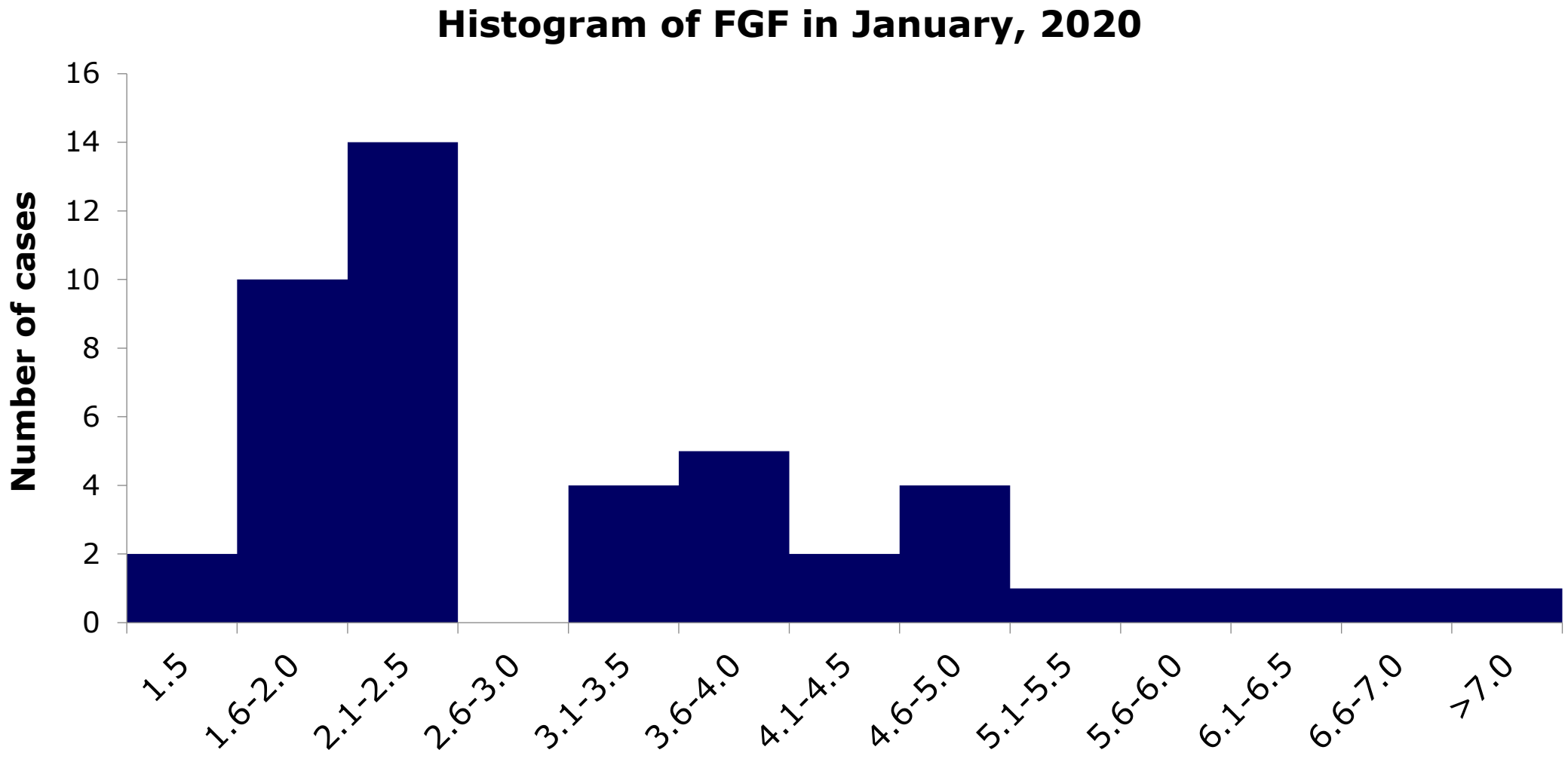
Table 1. Elements of Emissions Calculations

Agent	Molecular Weight (3)	GWP_{100} (3)	Max Vapor Flow	Minimum Alveolar Concentration	Max FGF
Sevoflurane	200g/mol	144	40mL/min	2-2.4%	1.6L/min
Isoflurane	184.5g	565	11mL/min	1.2-1.8%	0.65L/min
Desflurane	169g	2540	2.6mL/min	6.8%	0.04L/min
Nitrous Oxide	44g	282	92mL/min	1L/min	5 min

Interventions



Visualizing Statistics, Fresh Gas Flow



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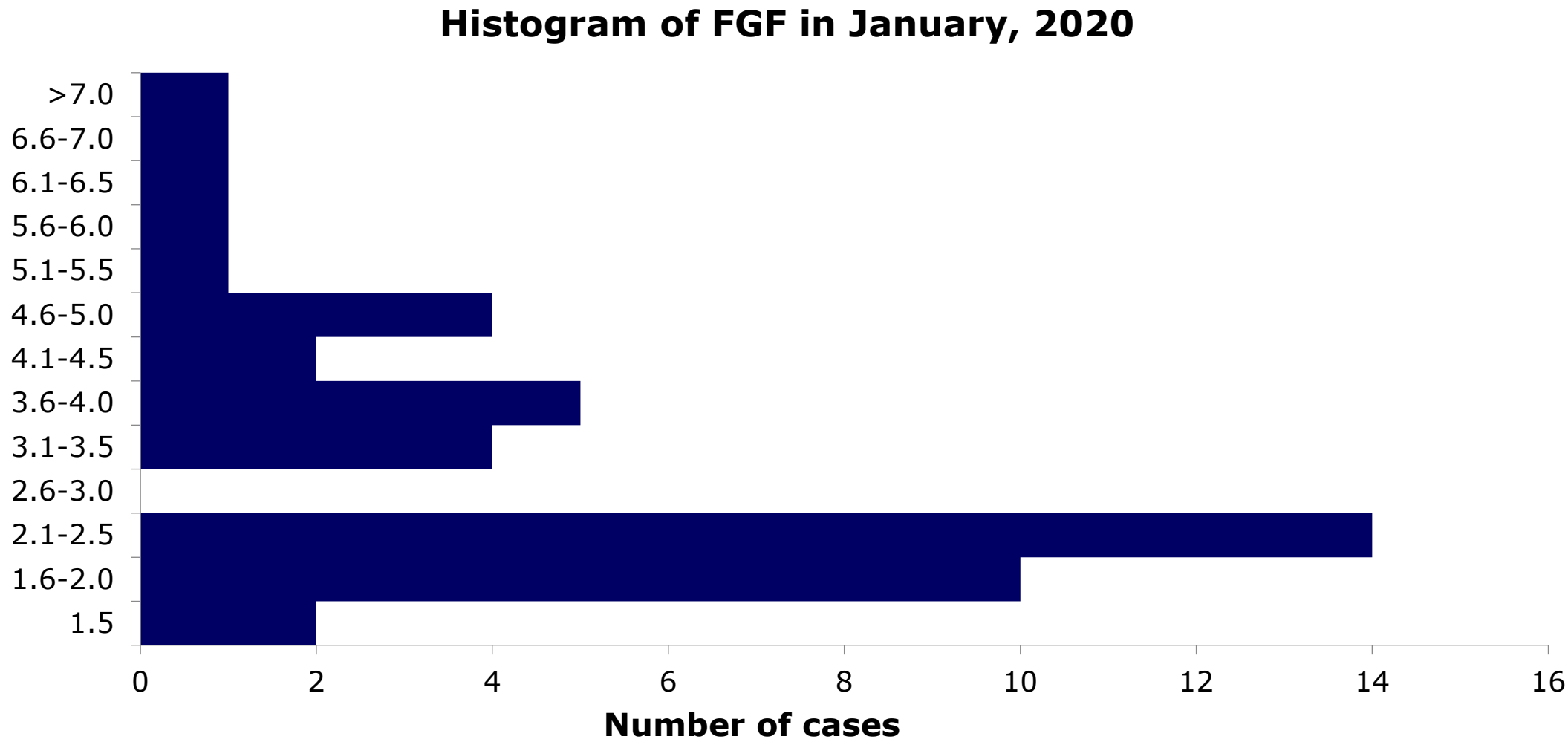

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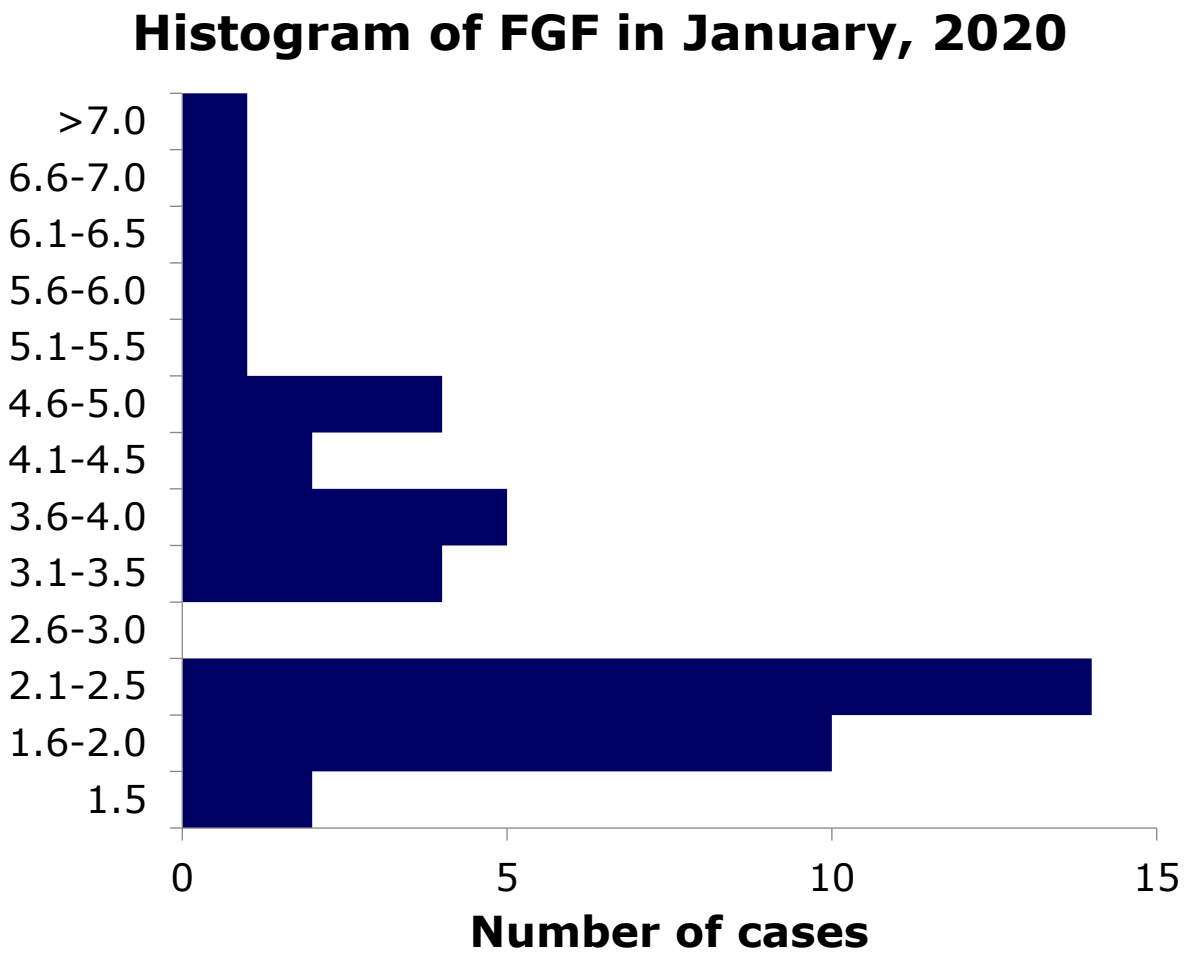

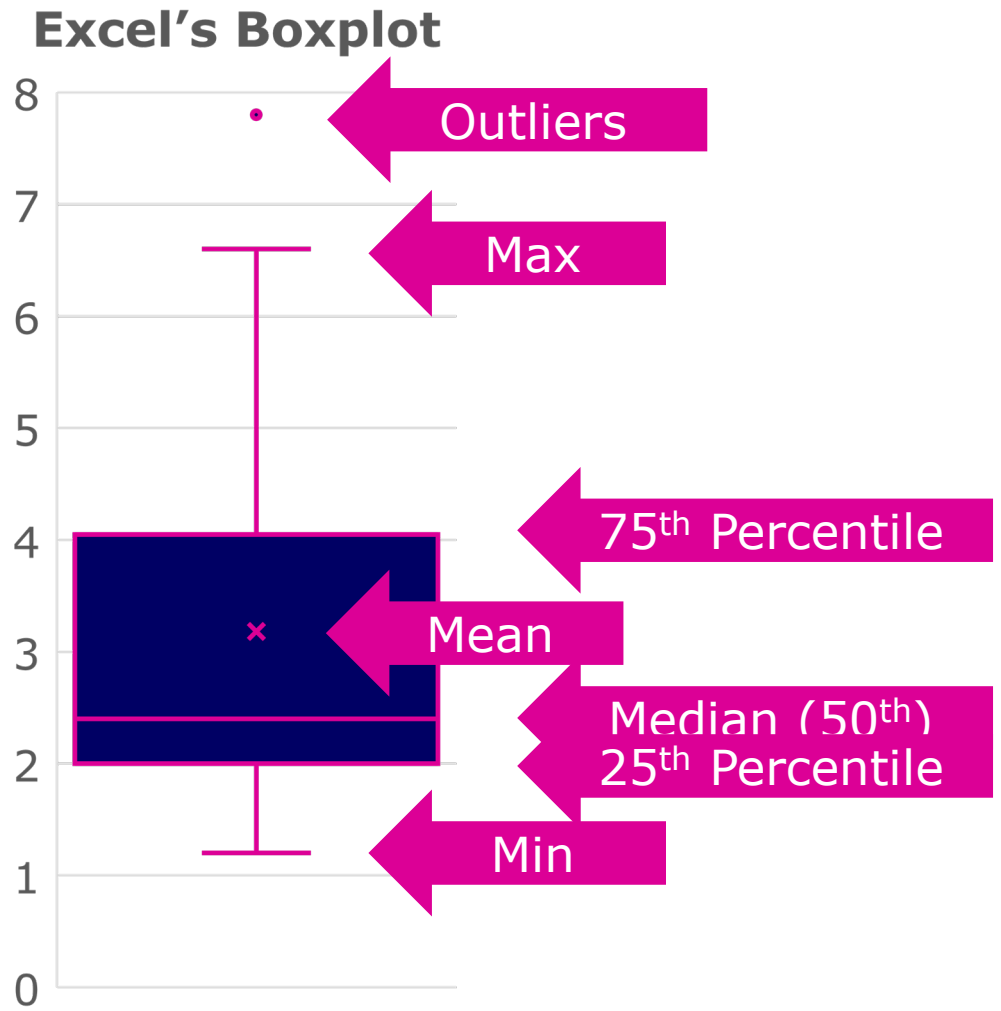

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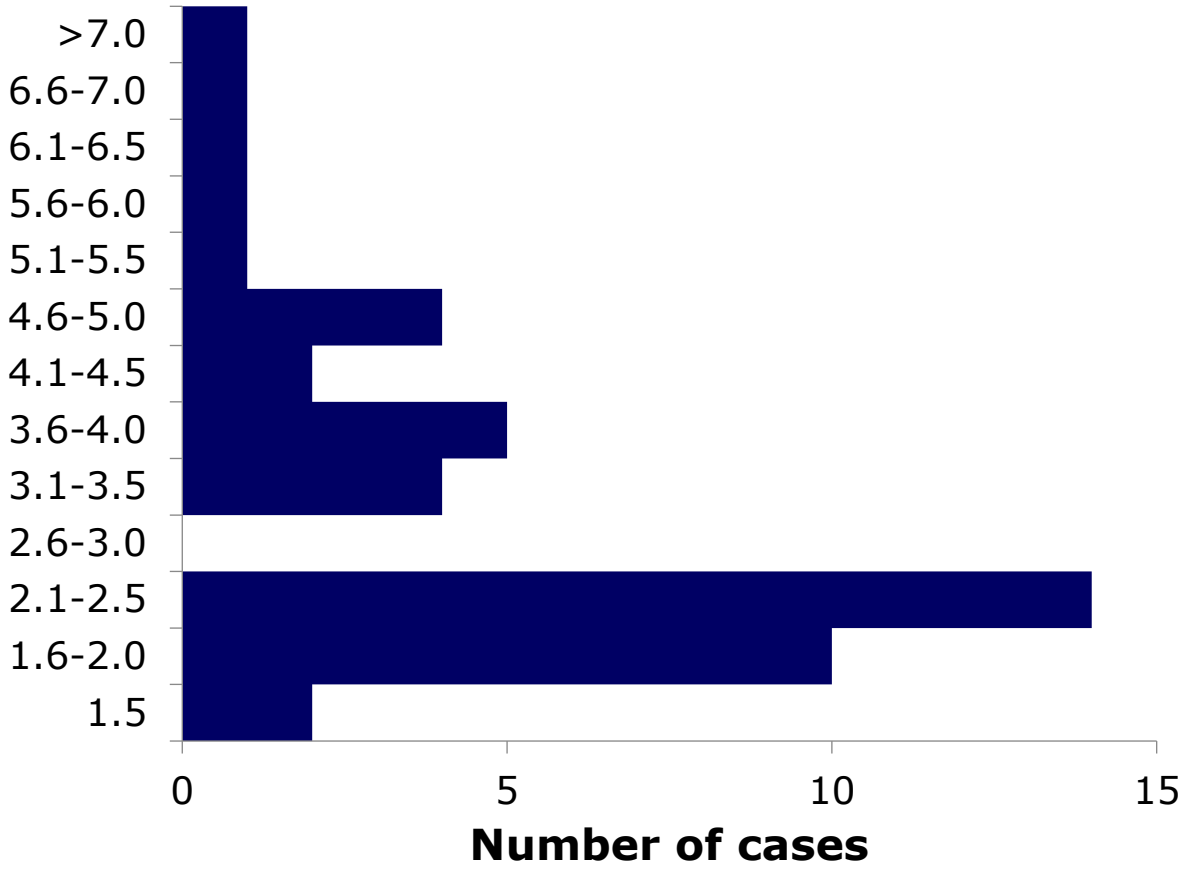

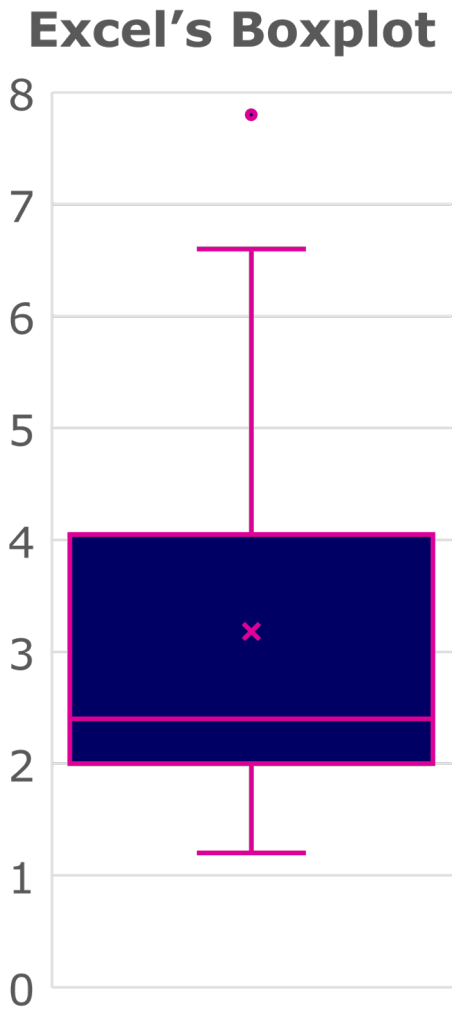

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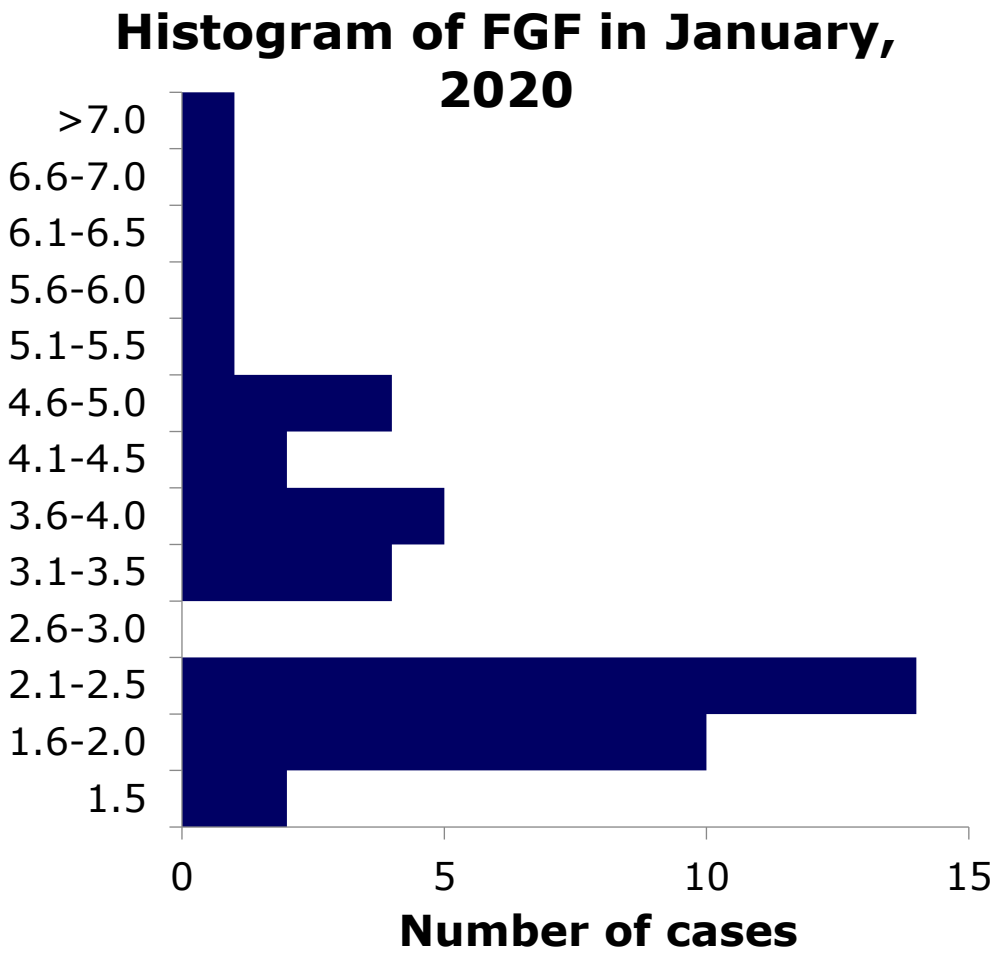
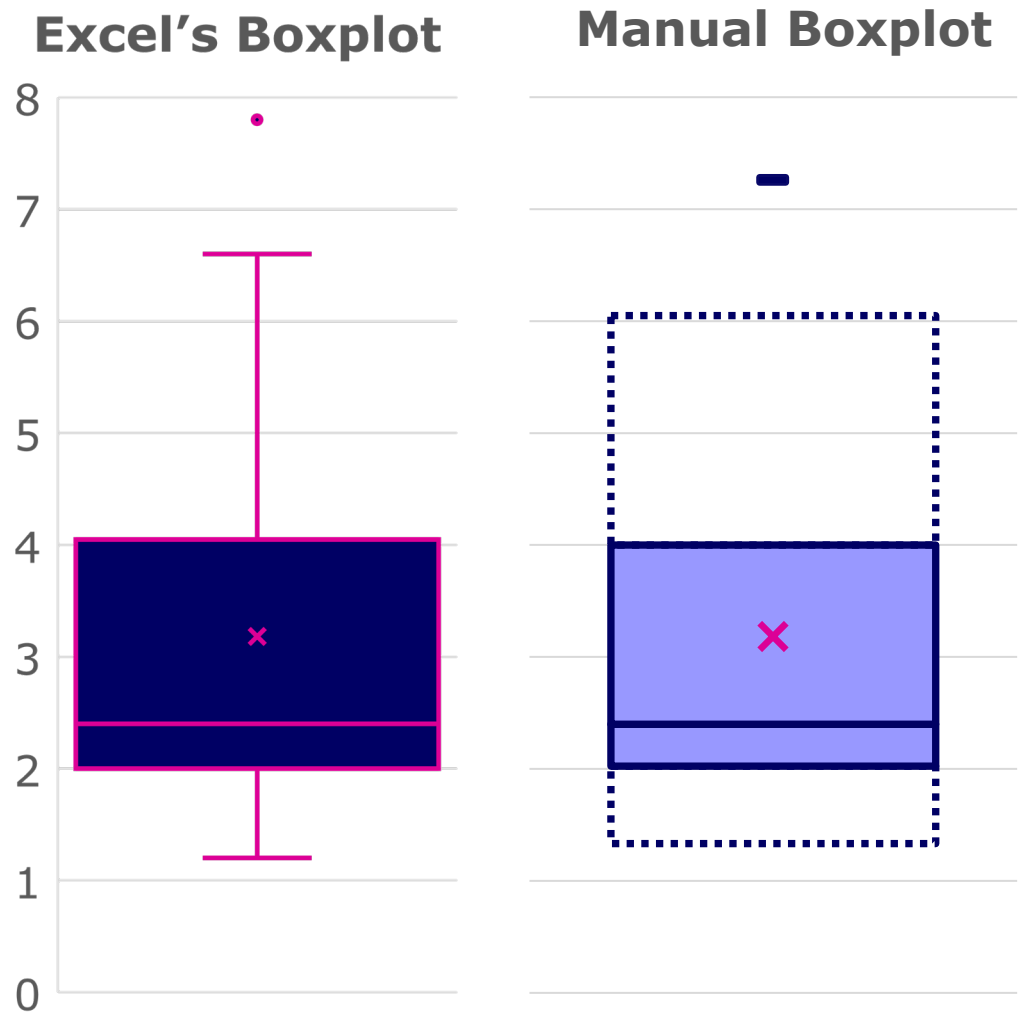
Visualizing Statistics, Fresh Gas Flow





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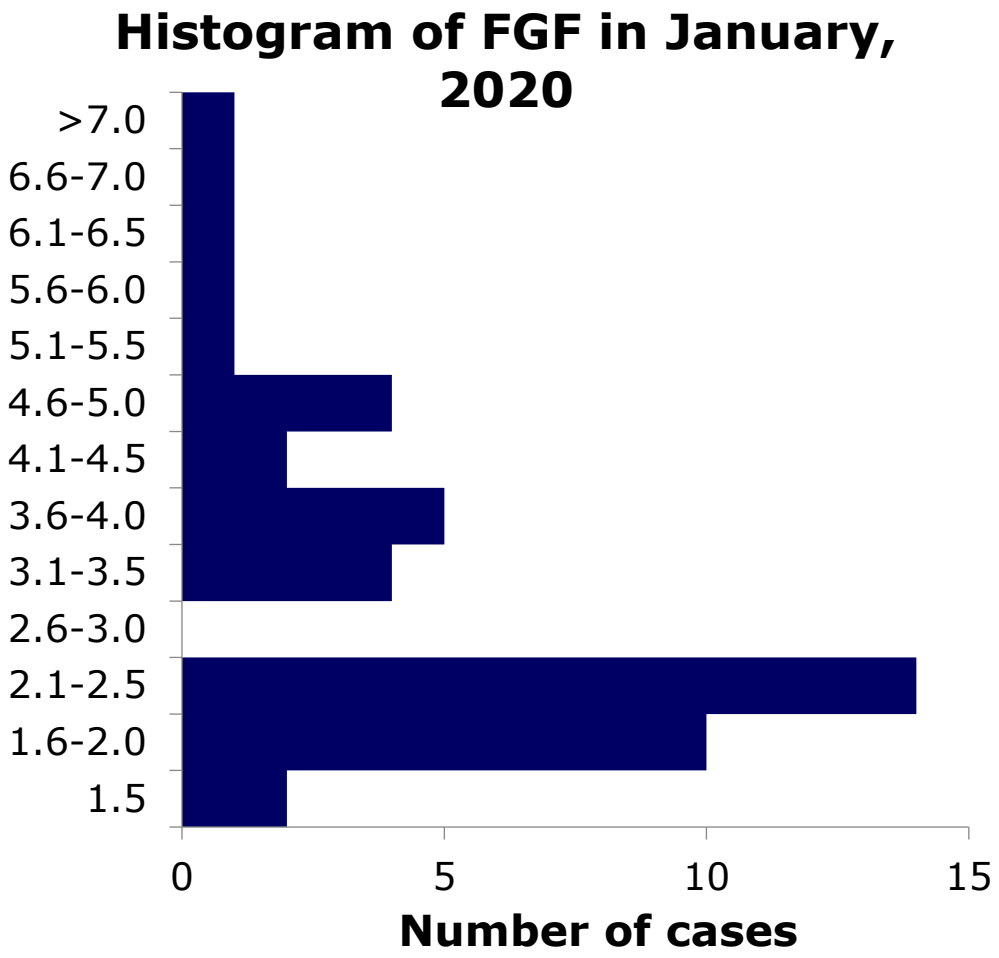

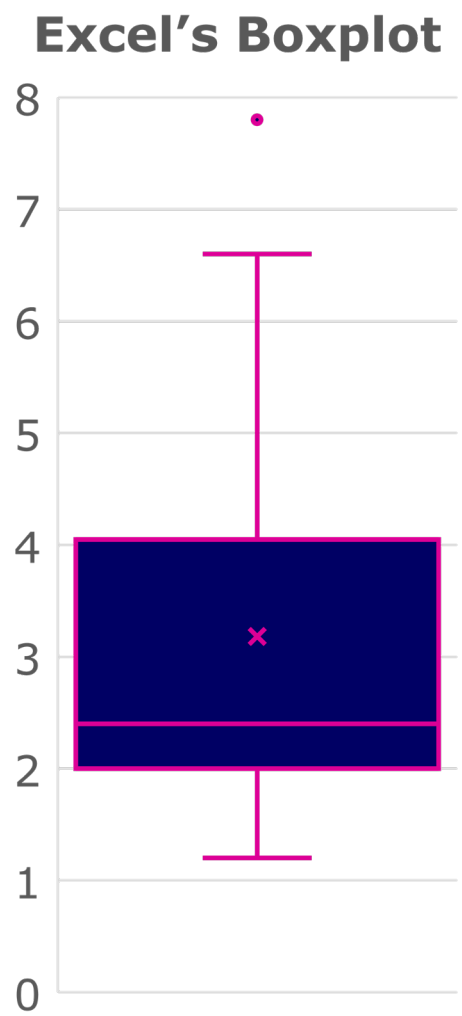

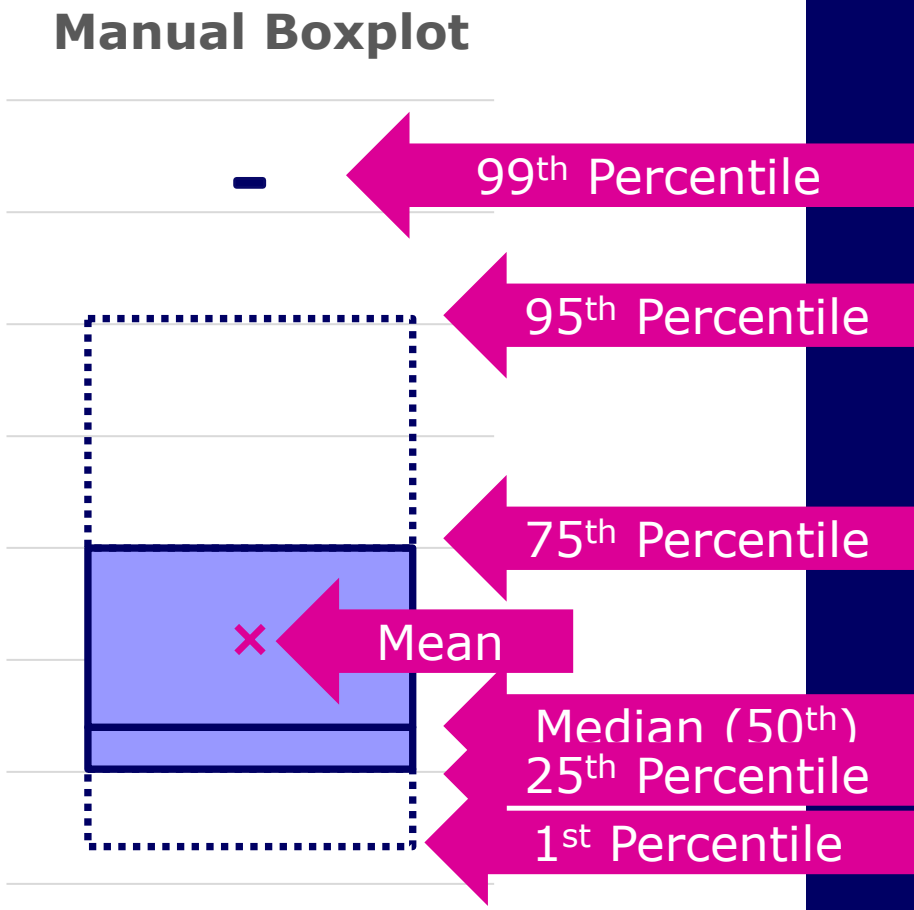

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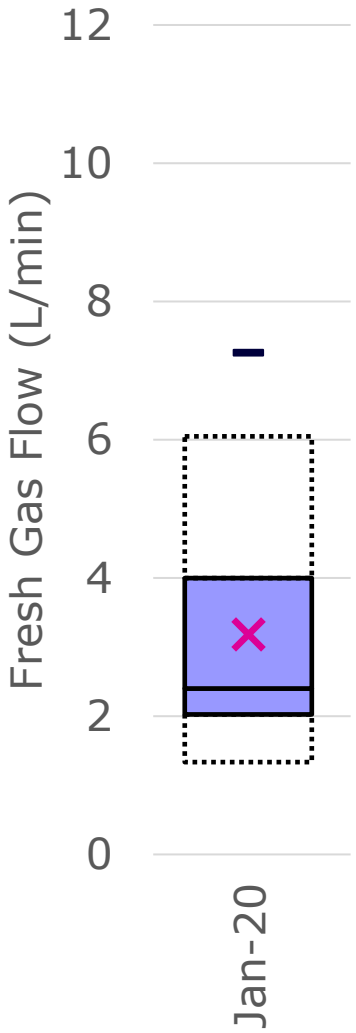
Focus on Mean Fresh Gas Flow

Mean Fresh Gas Flow Rate, Distribution of Cases



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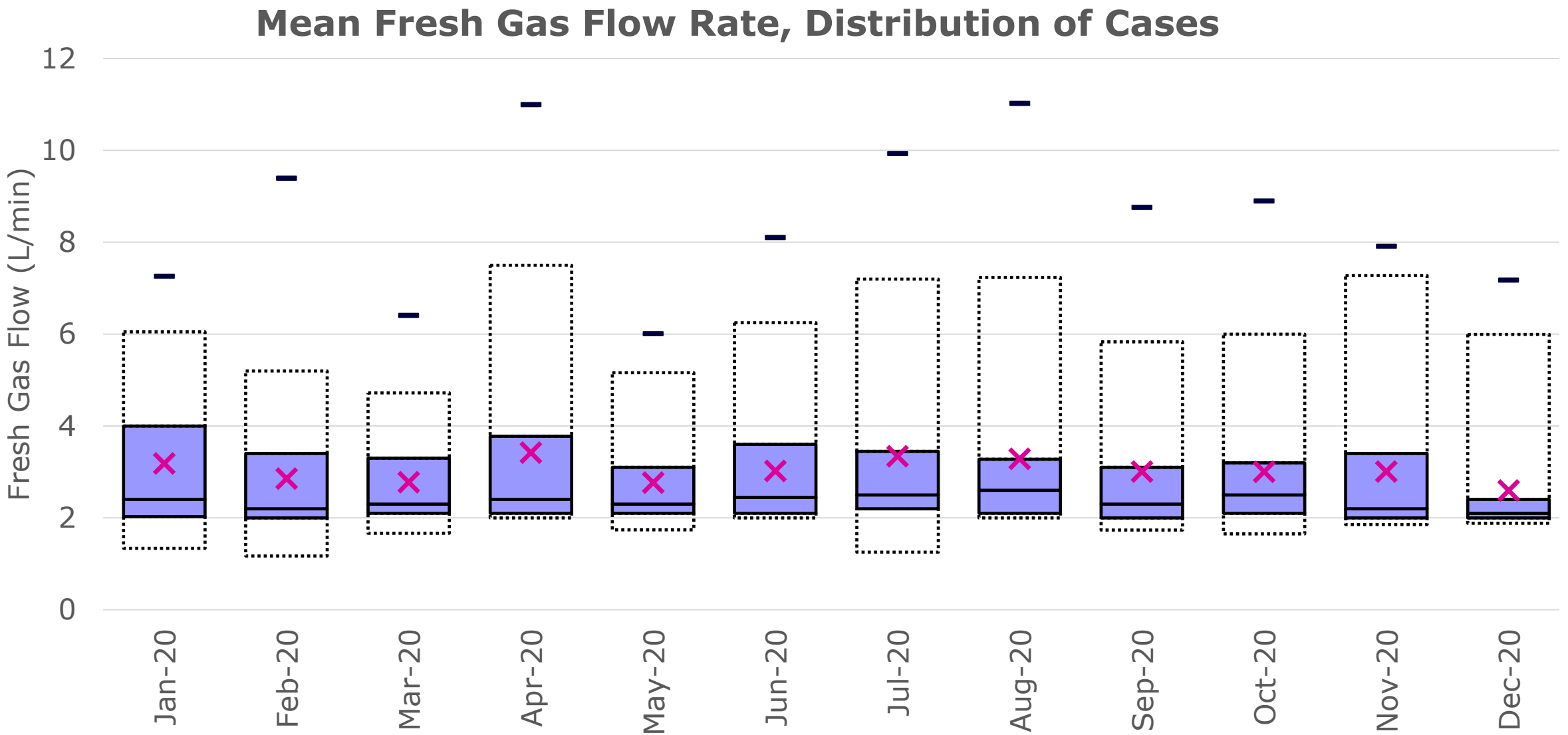

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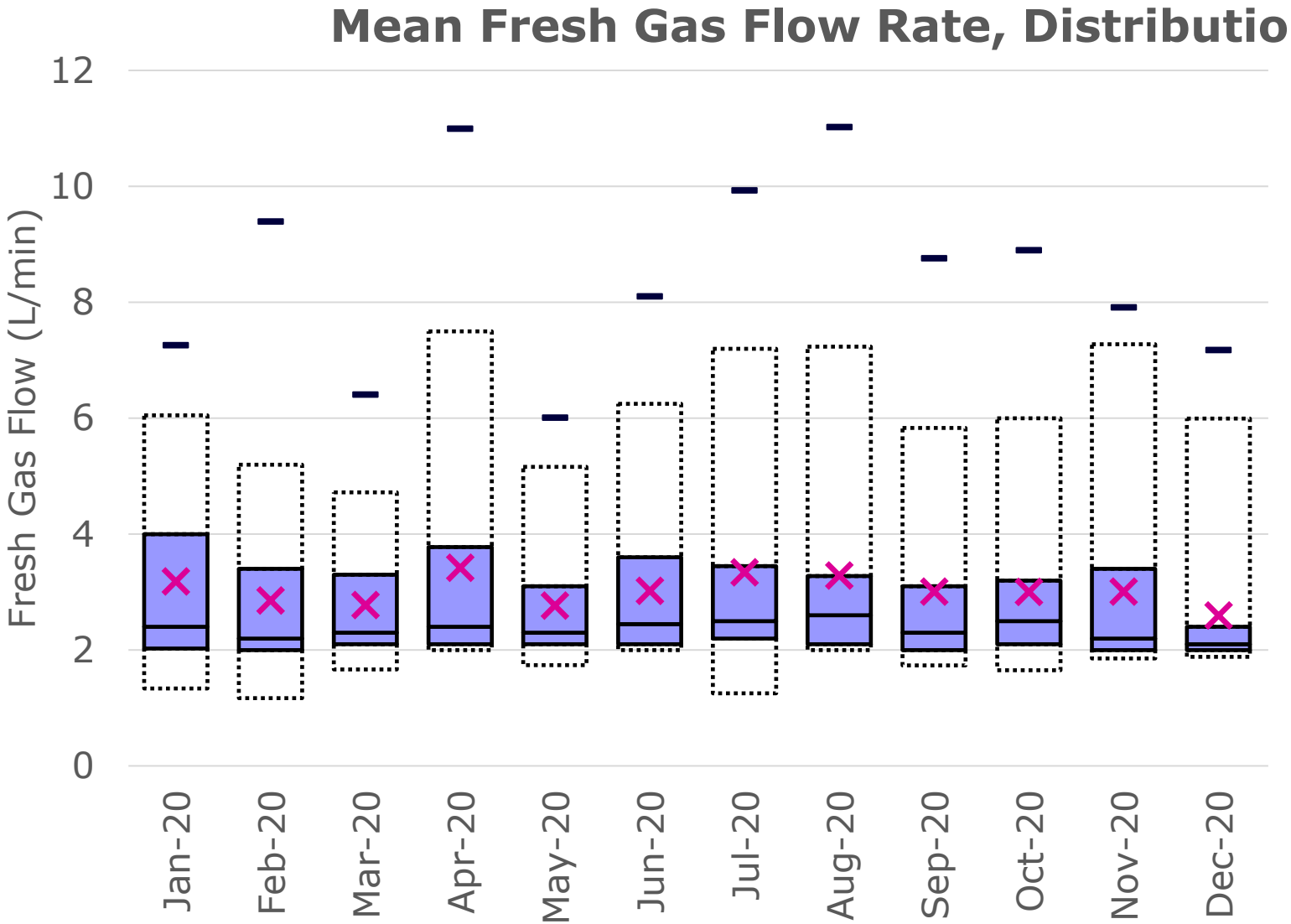

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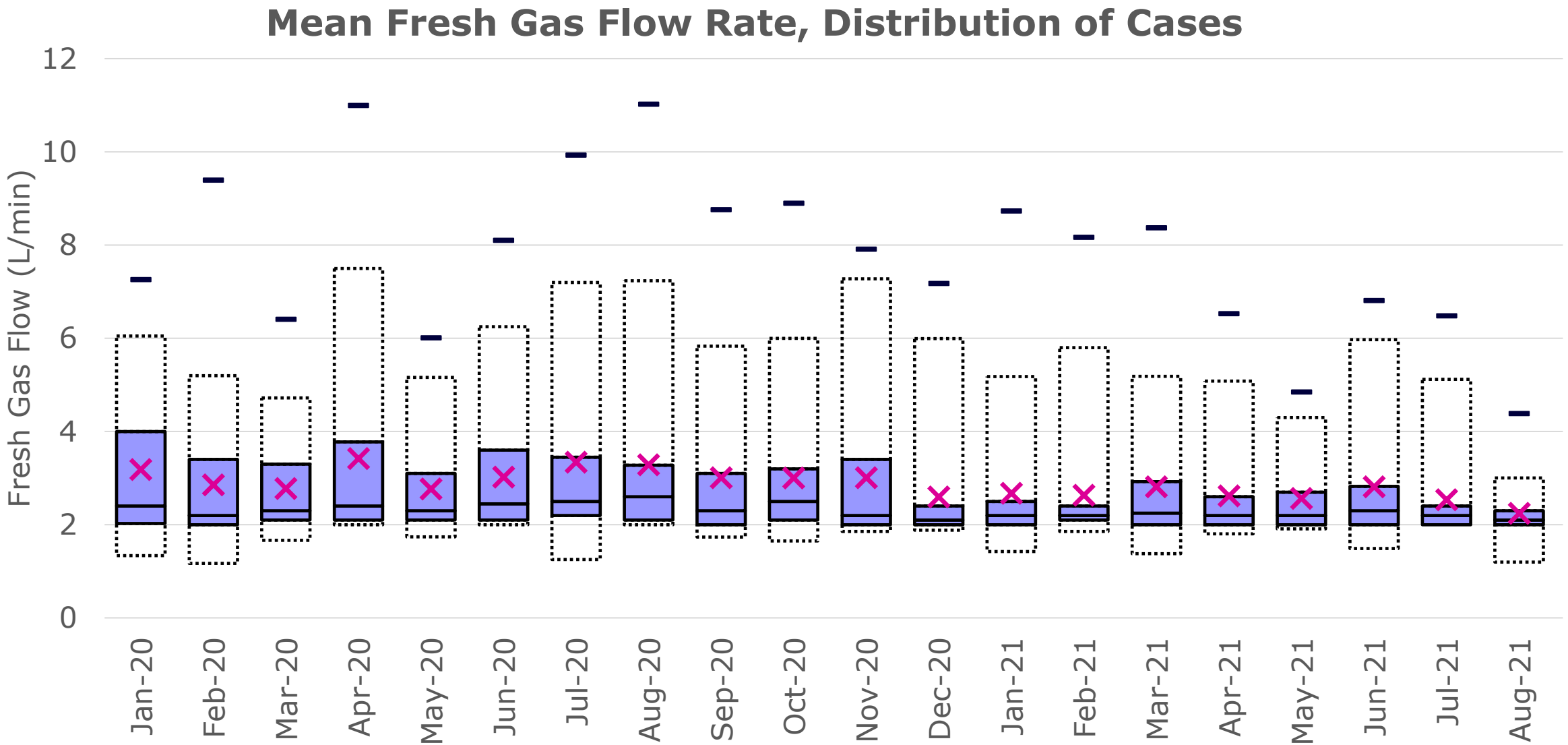

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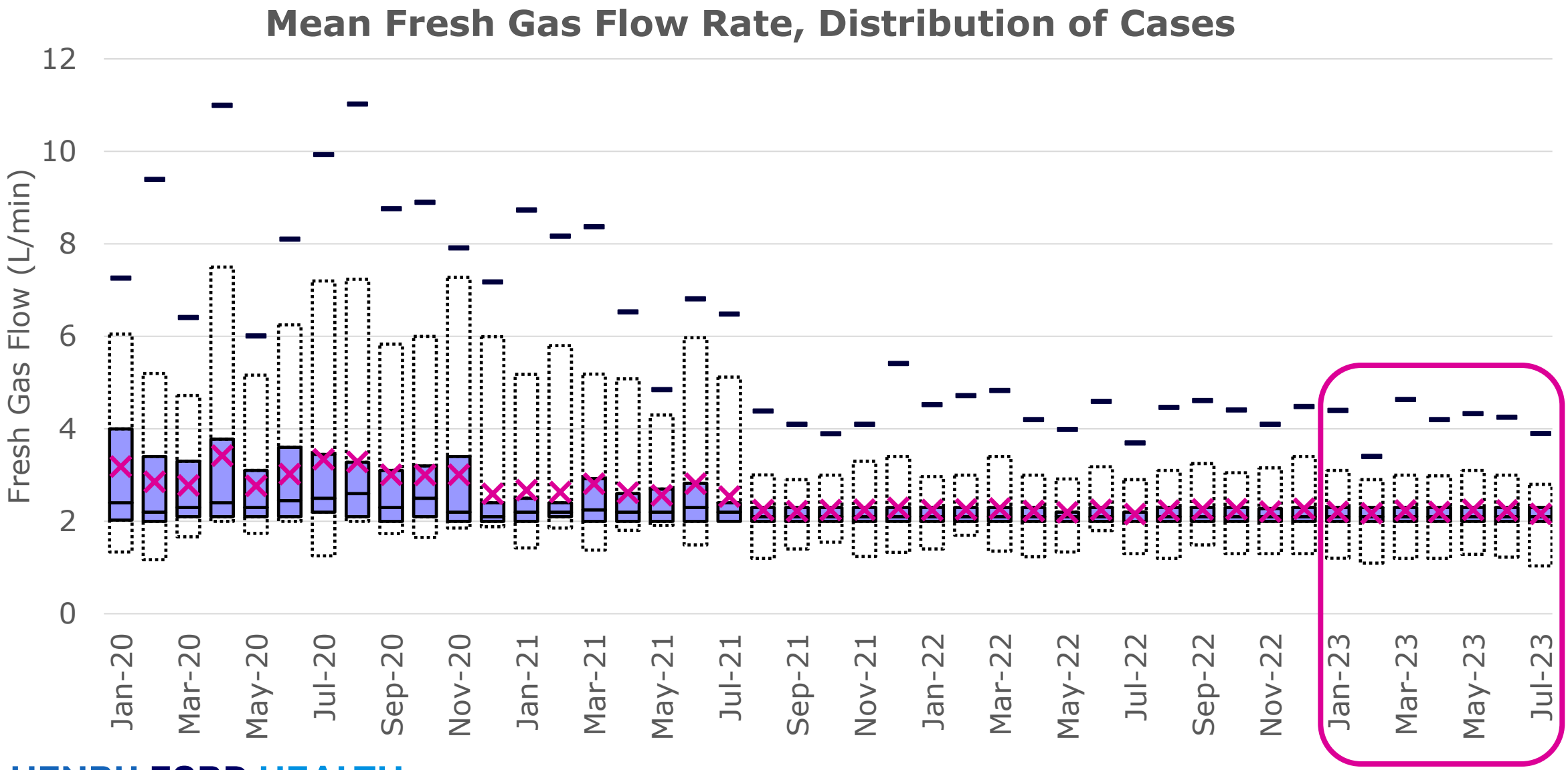

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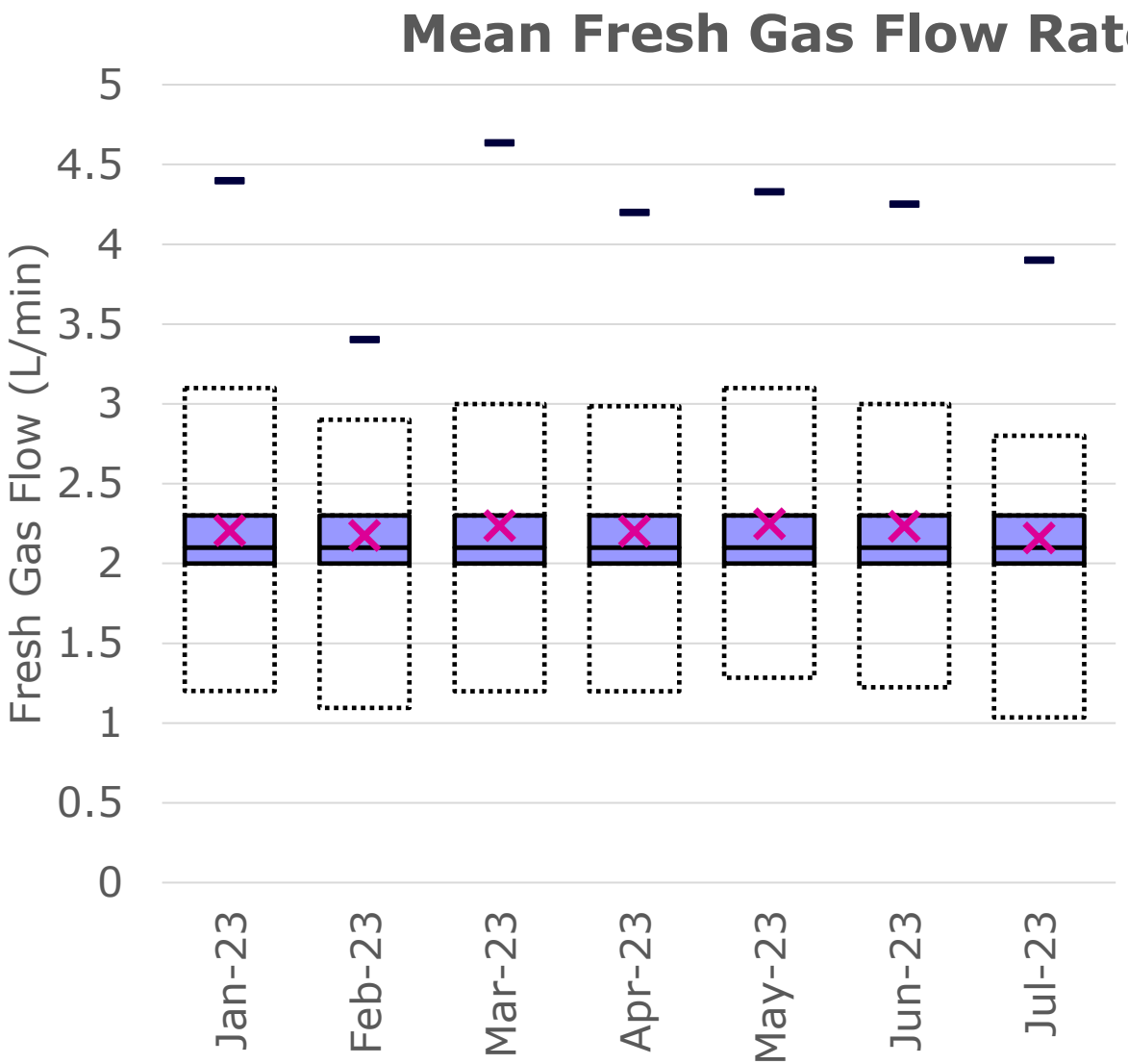

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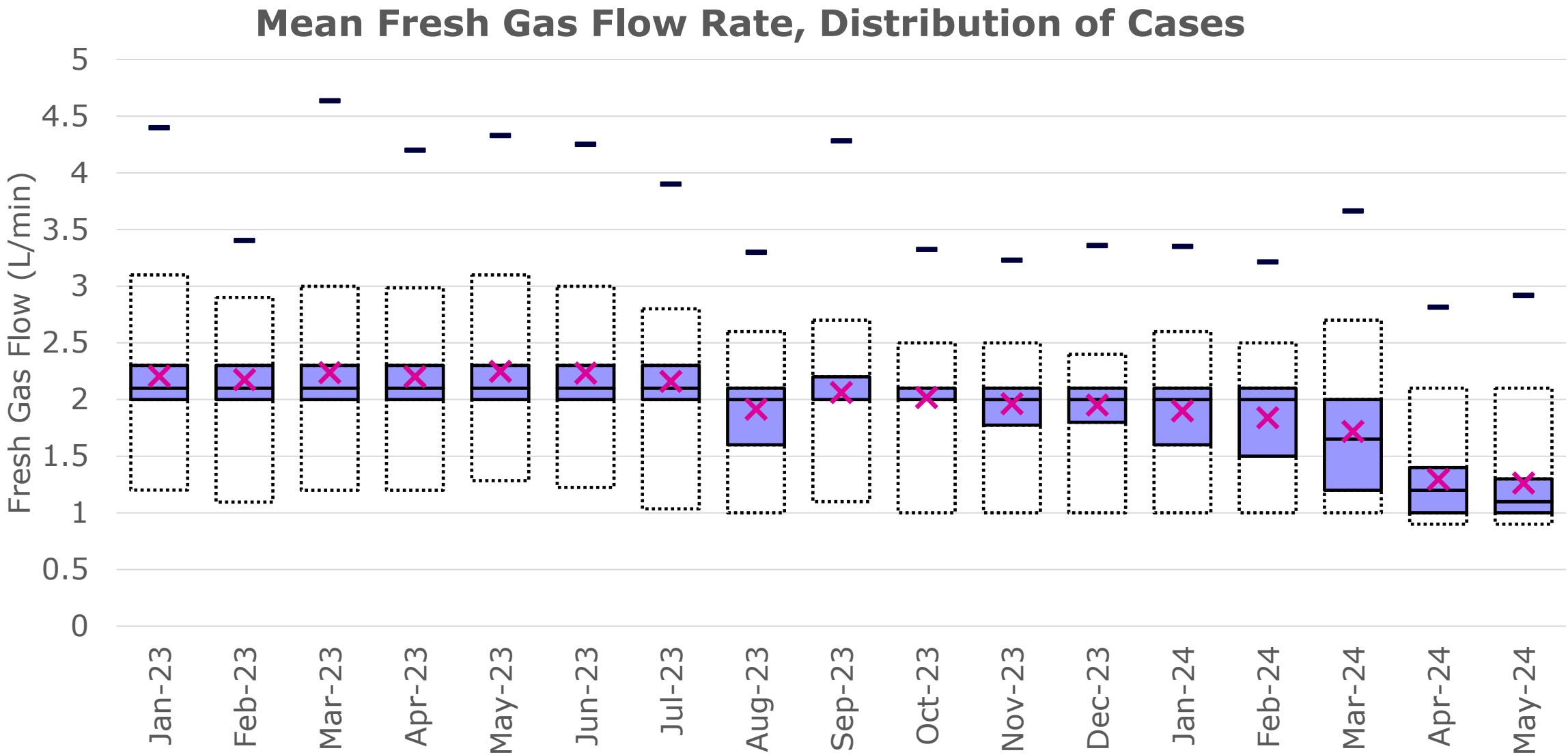

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Figure 2. July 2023

Any use of N_2O disproportionately increases both total case emissions and average hourly emissions.

N_2O accounted for:	July '23
Percentage of all maintenance anesthesia emissions	52.2% (3391kg)
Percentage of cases	34.0%
Percentage of total maintenance minutes	8.1%

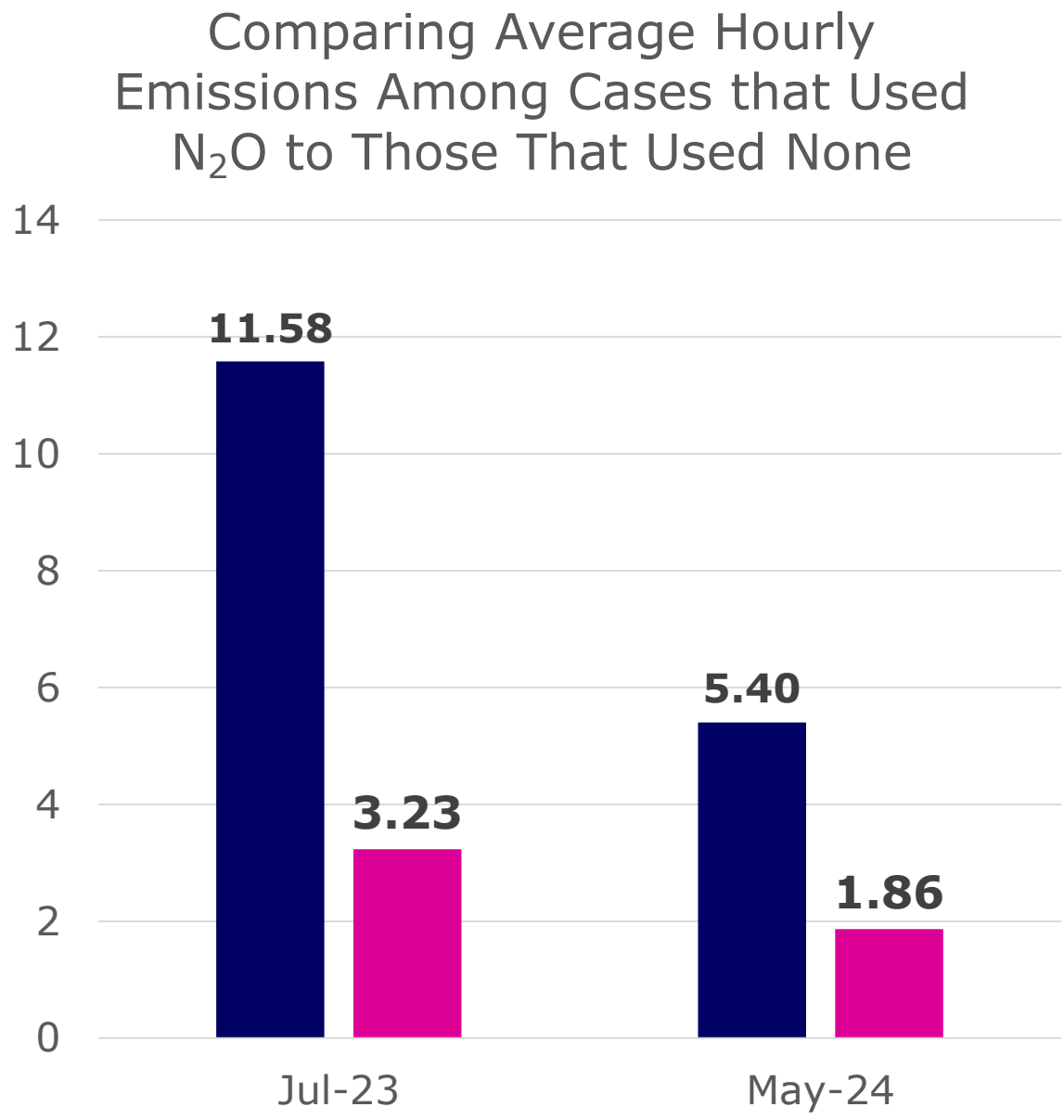

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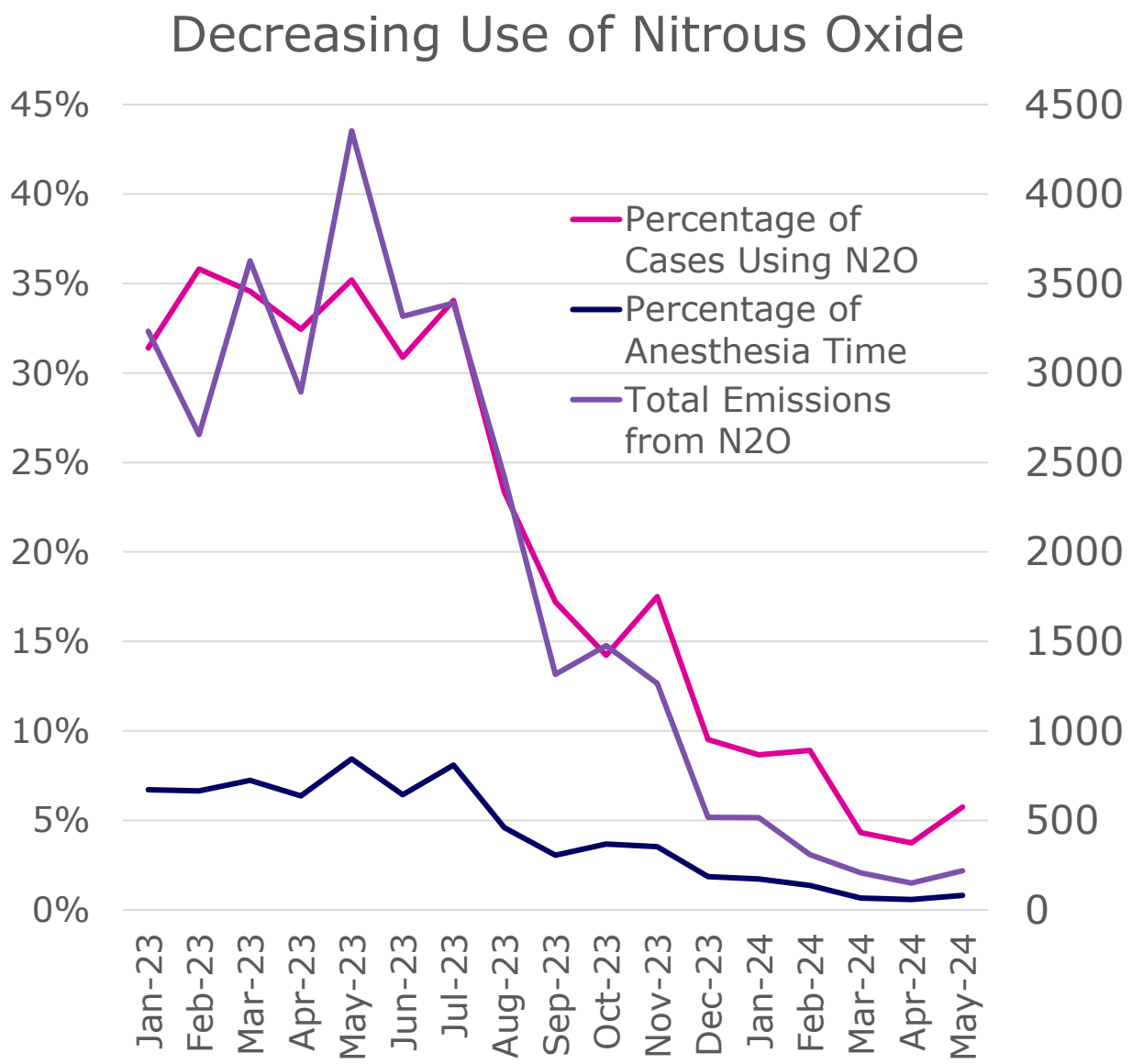
Figure 2. July 2023

Any use of N_2O disproportionately increases both total case emissions and average hourly emissions.

N_2O accounted for:	July '23	May '24
Percentage of all maintenance anesthesia emissions	52.2% (3391kg)	11.2% (218kg)
Percentage of cases	34.0%	5.7%
Percentage of total maintenance minutes	8.1%	0.8%



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Average Hourly Emissions during Maintenance Anesthesia

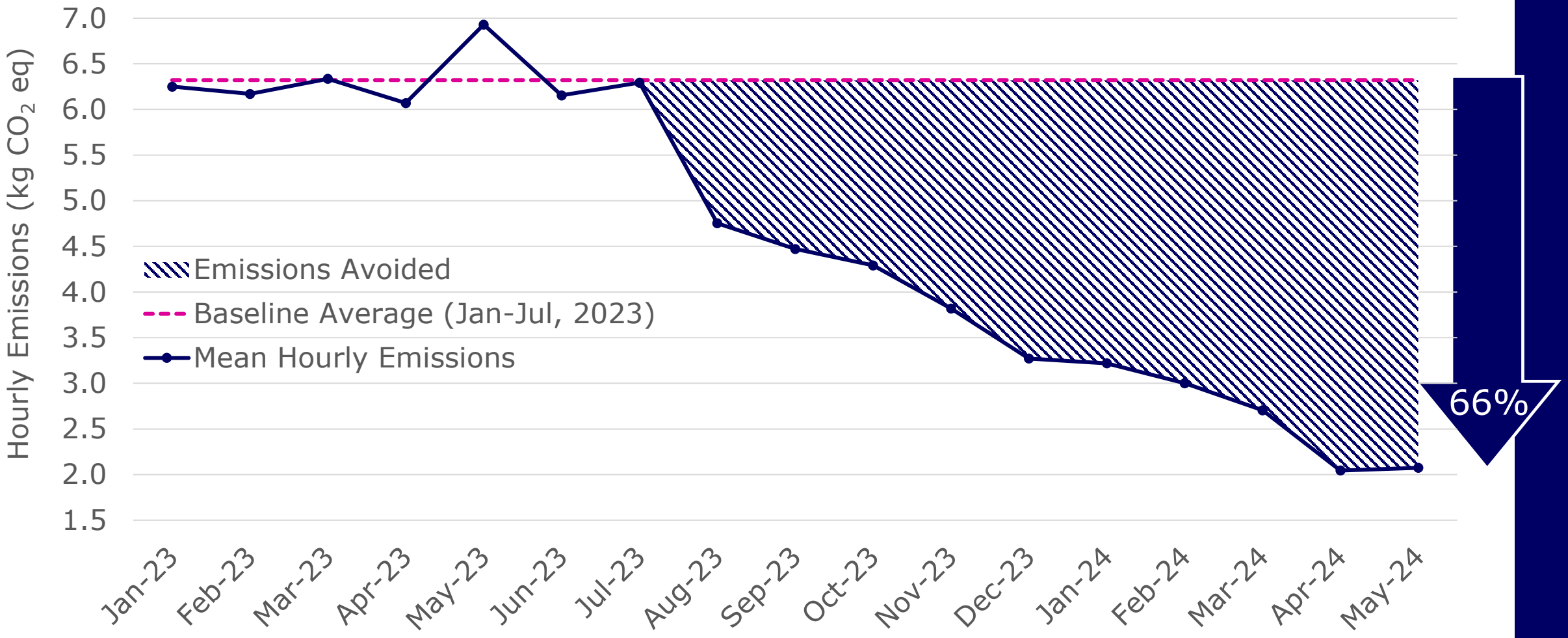

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Figure 3.

Average Hourly Emissions during Maintenance Anesthesia

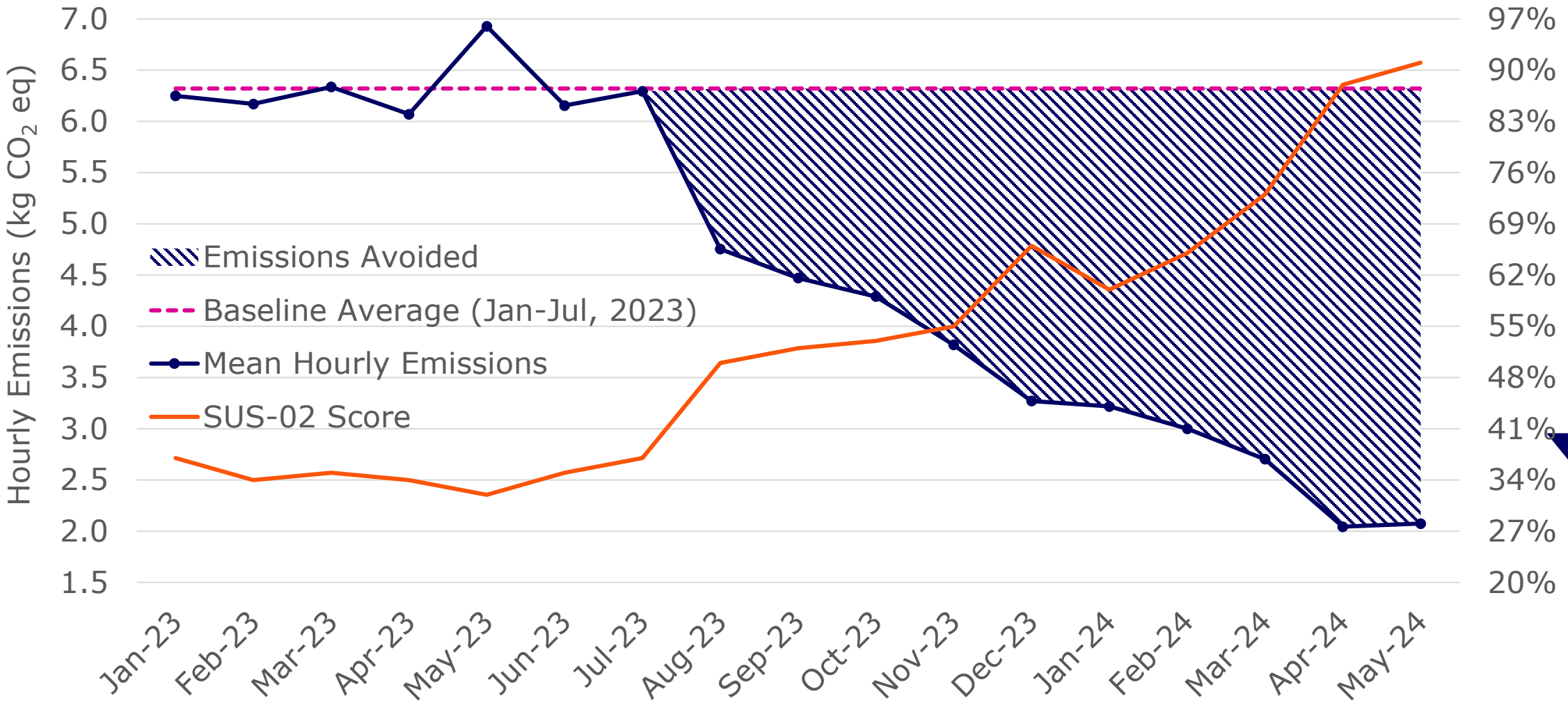

Figure 3.

Dewey Durant Park

East Tawas, MI

35.5 acres

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Results

Sustainability measure	Goal	Outcome achieved
SUS-01: Cases with mean Fresh Gas Flow ≤ 3L/min	95%	97% for 2023
SUS-02: Cases with mean hourly CO_2 equivalent ≤ 2.83kg/hour	45%	• 35% Jan-July 2023 • 56% Aug-Jan 2024 • 80% Feb-May 2024
Monthly mean hourly emissions	40% reduction	January's mean hourly emissions are 50% below baseline
Total emissions avoided since August	n/a	>30,400kg CO_2 eq

Conclusions

- Considering the greenhouse gas effect of inhaled anesthetics is a paradigm shift in this practice of medicine.
- A focus on fresh gas flows can have a profound impact on hourly and total emissions.
- There are differential global warming effects of various agents. Specifically, avoiding routine use of nitrous oxide can further reduce emissions.
- Participation in the Anesthesia CQI-sharing metrics and targets can elevate issues of environmental sustainability in the administration of anesthetics.
- Results for other Henry Ford Health System hospitals are catching up.

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1. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press; 2023. doi:10.1017/9781009325844
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Reducing Greenhouse Gas Emissions in Jackson: A CQI Story about the Triumphs of Science and Collaboration in Changing Clinical Operations

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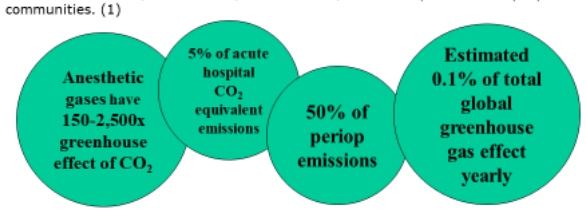
Abstract

The climate change crisis threatens human health by adversely affecting the spread of infectious disease, malnutrition, mental health, and the displacement of people or communities. (1)



The Anesthesiology Performance Improvement and Reporting Exchange (ASPIRE) is a project of the Multicenter Perioperative Outcomes Group (MPOG) Collaborative Quality Initiative (CQI). Their sustainability goal is to help reduce greenhouse gas emissions from anesthesia waste used in the US by optimizing environmentally-safer anesthesia agents and managing fresh gas flow.

Aim

- MPOG goal: at least 45% of cases in 2024 will have an average hourly emissions profile of 2.83kg CO_2 equivalents per hour of maintenance anesthesia.
- At Henry Ford Jackson Hospital (HFJH): average hourly emissions were 6.32kg CO_2 eq/hr. We seek to reduce that average hourly emissions rate each month by 40% by February 2024 and maintain that level into the future.

Measures:

- Sustainability Goal 01 (SUS-01): Percent of cases with mean fresh gas flow (FGF) during maintenance anesthesia of ≤3L/min, target 95%
- Sustainability Goal 02 (SUS-02): Percent of cases where mean hourly CO_2 eq is less than the CO_2 eq of 2% sevoflurane at 2L/min FGF = 2.83kg CO_2 eq/hr, target 45%
- Monthly Mean of Hourly Emissions
- Calculating CO_2 equivalents is based on:
  - Vapor Flow = FGF x Percent Agent
  - GWP^{100} = Global warming potential is a multiplier to approximate comparative global warming effect of a chemical to CO_2 over a 100-year timeframe
  - Molecular weight = GWP to calculate CO_2 eq is based on the same mass of chemical

Agent	Molecular Weight (3)	GWP^{100} (3)	Max Vapor Flow	Minimum Alveolar Concentration
Sevoflurane	200g/mol	144	40mL/min	2-2.4%
Isoflurane	184.5g	565	11mL/min	1.2-1.8%
Desflurane	169g	2540	2.6mL/min	6.8%
Nitrous Oxide	44g	282	92mL/min	1L/min

Interventions

Date	Action
August 2021	Reduced default Fresh Gas Flow rate in all anesthesia machines at HFHS
July 2023	Joint education session for CRNAs and anesthesiologists on technical mechanics of low flow anesthesia (<1L/min)
August 2023	Clinical education around performance, reliability of previous target (3L/min), with encouragement toward target below 2L/min
November 2023	Education about SUS-02 metric, how it is calculated, and how to meet metric; shared performance data from August-September
January 2024	Data show reductions in two areas: 1. Use of highest emission gases 2. Use of fresh gas flows

Baseline Data

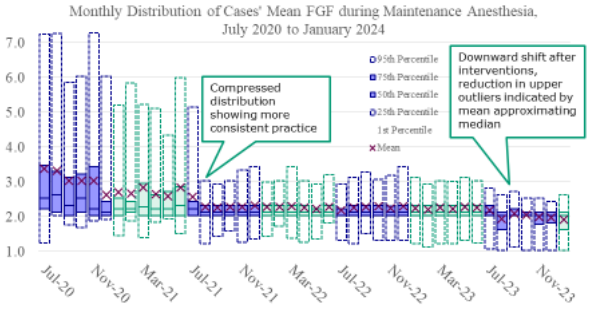


Figure 1. Boxplots show the distribution of case mean FGF, month by month. SUS-01 metric was introduced during 2020. By August 2021, the distribution had compressed showing more consistent practice. Each boxplot also shifted down reflecting lower flows. Additional reductions began in August 2023 after education with centralization of the mean to the median.

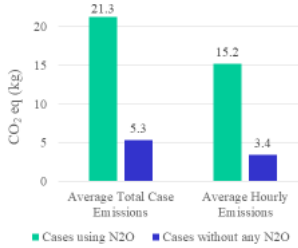


Figure 2. July 2023. Any use of N_2O disproportionately increases both total case emissions and average hourly emissions. In July, N_2O represented over 50% of total anesthetic gas emissions as measured in CO_2 equivalents, **reduced to 15.3% in January.**

Results

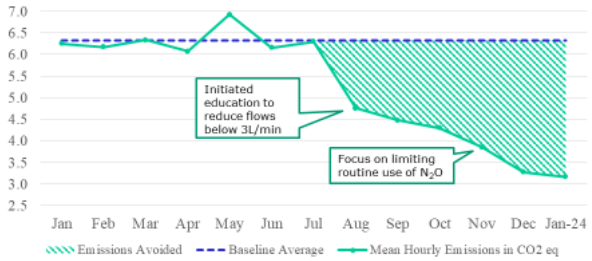


Figure 3. Monthly mean hourly emissions in kg CO_2 eq. Six consecutive months of decreasing emissions.

Sustainability measure	Goal	Outcome achieved
SUS-01: cases with mean Fresh Gas Flow ≤ 3L/min	95%	97% for 2023
SUS-02: Cases with mean hourly CO_2 equivalent ≤ 2.83kg/hour	45%	• 35% Jan-July 2023 • 56% Aug-Jan 2024
Monthly mean hourly emissions	40% reduction	January's mean hourly emissions are 50% below baseline
Total emissions avoided since August	n/a	>14,600kg CO_2 eq

Conclusions:

- Considering the greenhouse gas effect of inhaled anesthetics is a paradigm shift in this practice of medicine.
- A focus on fresh gas flows can have a profound impact on hourly and total emissions.
- There are differential global warming effects of various agents. Specifically, avoiding routine use of nitrous oxide can further reduce emissions.
- Participation in the Anesthesia CQI-sharing metrics and targets can elevate issues of environmental sustainability in the administration of anesthetics.
- Results for other Henry Ford Health System hospitals will be available after implementing similar interventions starting in December 2023.

Bibliography

1. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press; 2023. doi:10.1017/9781009325844
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