Low Flow Anesthesia with Sevoflurane: Project Evaluation

Russell Lynn Memorial Student Lecture Series

Victoria Grant BSN, RN, CCRN, RRNA
Emily Sassano BSN, RN, CCRN, RRNA
Rutgers Doctoral Program in Nurse Anesthesiology
DNP Chair: Dr. Michael McLaughlin, DNP, CRNA, APN

Purpose Statement

It was established last year by implementation of "Low Flow Anesthesia with Sevoflurane" quality improvement project that low flows decreased cost and environmental waste without causing harm to the patient. We want to evaluate if this change in practice was sustainable, identify the project's effective strategies, determine if additional training or education is needed, and make plans to continue to improve the project in the future.

Clinical Question

Did the quality improvement project implemented at Robert Wood Johnson University Hospital by Villegas and Zarsadias (P) to utilize low flow anesthesia to curb environmental pollution and hospital cost (I) have a sustained impact on anesthesia providers at the institution (O) from final analysis of 200 patients from 10/18/2023 to 11/11/2023 (T) when compared to initial project completion by Villegas/Zarsadias (C)?

Background and Significance

Observed practice change:

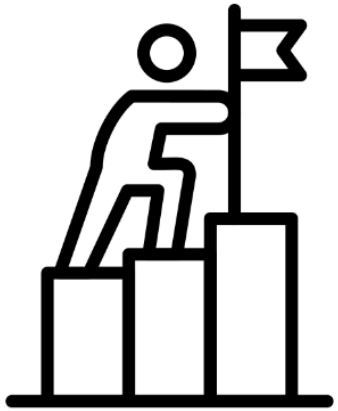
- Villegas and Zarsadias's (2022) quality improvement project demonstrated the efficacy of provider education, visual reminders, and continuous reinforcement on changing flow rate practices.
    - There was a significant difference between pre- and post-intervention FGF rates ($p = 0.001$), which overall, significantly decreased the release of sevoflurane into the atmosphere. Further, the adopted practice led to an estimated 25% cost reduction for the hospital.
- While their original results demonstrated a significant reduction in FGF rates and hospital cost, the sustainability of their project has not been examined.

Why we should evaluate:

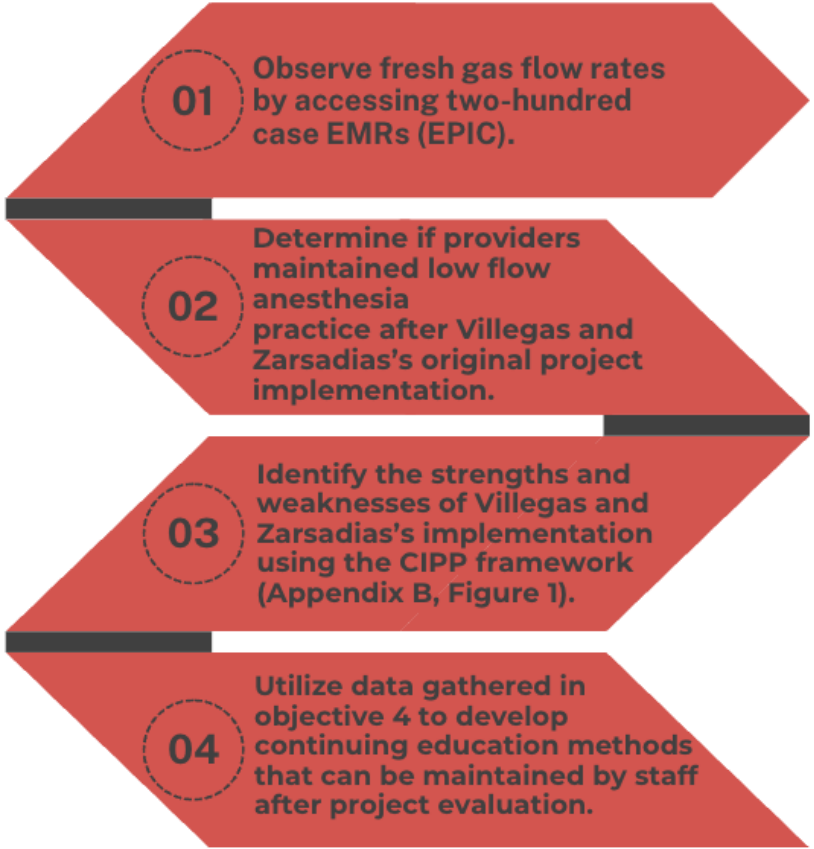
- Program evaluation is essential to ensure programs are designed to successfully meet their defined objectives.
- By performing a program evaluation on the previous quality improvement project, we will be able to identify gaps in Villegas and Zarsadias's project, and implement continuing education methods to bolster its sustainability and impact.

Project Goals

- Evaluate the initial implementation effectiveness in producing a practice change by analyzing EMR data of actual flows used when delivering sevoflurane.
- Utilize the Context, Input, Process, & Products (CIPP) framework to identify methods to review components of initial quality improvement project that promote sustainability to low flow anesthetic practice.
- Offer continuing education methods that can be maintained by staff after project evaluation.



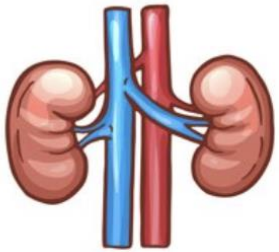
Aims & Objectives



Synthesis of Literature

Biological impact

- Renal function is not altered in patients who undergo surgery with low-flow anesthesia (Sondekoppam et al., 2020)
- The use of low-flow anesthesia may decrease oxidative damage postoperatively and help to quicken the healing process (Kaşıkara et al. 2022)



Environmental Impact

- Sevoflurane is a greenhouse gas with a 100 year global warming potential of 130 and atmospheric lifetime of 1.1 years (Zuegge et al., 2019). Utilization of sevoflurane at high flows results in unnecessary heat accumulation in the atmosphere and increased sevoflurane consumption.
- Edmonds et al. (2021) calculated that the use of low flow anesthesia allowed patients to rebreathe about fifty percent of expired anesthetic agent, preventing the release of excess sevoflurane into the atmosphere.

Synthesis of Literature

Financial Impact

- Edmonds et al. (2021) computed that if the average FGFs at a Pacific Northwest medical center were 1.5L/min and 1.0L/min, that 353 and 578 bottles of sevoflurane could have been prevented from entering the atmosphere, respectively. Authors also predicted the cost reduction associated with decreased flows; rates of 1-2L/min had a potential savings of $6,997 and $19,424, and rates of 1L/min were estimated to save $44,195 (Edmonds et al., 2021).
- Villegas and Zarsadias (2022) implementation produced an estimated 25% cost reduction for the hospital.

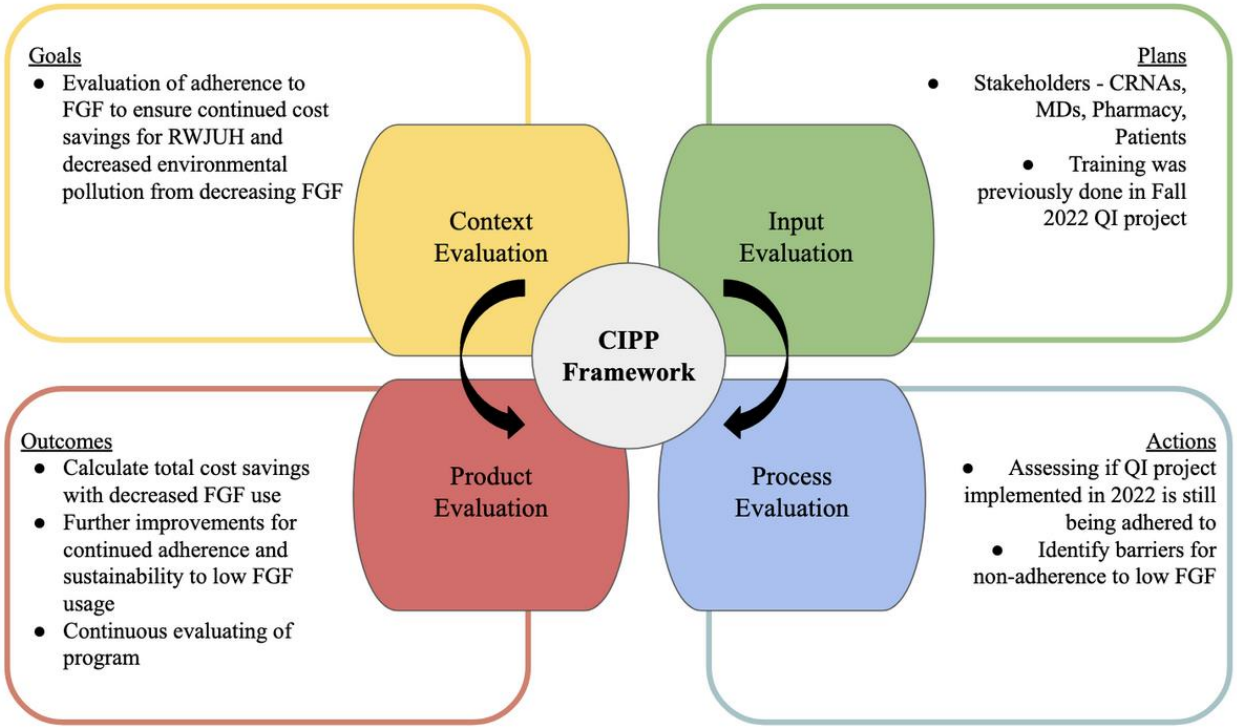
CIPP Framework

- Multiple evidence-based practice research papers showed how the CIPP model is a useful tool for comprehensive evaluation from project development to implementation (Toosie et al., 2021; Kim et al., 2022)
- Follow up using the CIPP model showed exceptional improvement to programs already in place
- The CIPP framework has also been very useful in determining if a program needs revision or should be terminated
    - Aids in finding program infrastructural issues and if proposed standards are not being met (Bilan et al., 2021)

Program Evaluation: Context, Input, Process & Products (CIPP) Framework

- **Context** - planning phase
  - Helps to define how the program functions and identify goals
    - Needs assessments, available resources, background, problems to be solved, and environment in which program takes place
- **Input** - structuring phase
  - Looks at what is required in order to meet needs of the context phase
- **Process** - implementation phase
  - Can be every changing based on program monitoring & feedback
- **Products** - review phase
  - Determine if initial problems were solved, if the project is sustainable, and where improvements can be made

CIPP Framework Model



Methodology

Design

- Retrospective chart review of intraoperative EMRs (EPIC).

Setting

- University level-1 trauma center located in Central New Jersey with 30 main operating rooms and 6 pediatric operating rooms.

Data collection

- FGF practices of anesthesia providers were assessed in 200 cases that met study inclusion criteria.
- Collection of data via an excel spreadsheet. Data collected included FGF rate during the maintenance phase of anesthesia, airway device used, ASA, provider specialty, and anesthetic agent used.

Data analysis

- Statistical analysis with SPSS was used to compare immediate FGF data to data collected between October-November 2023.

Methodology cont.

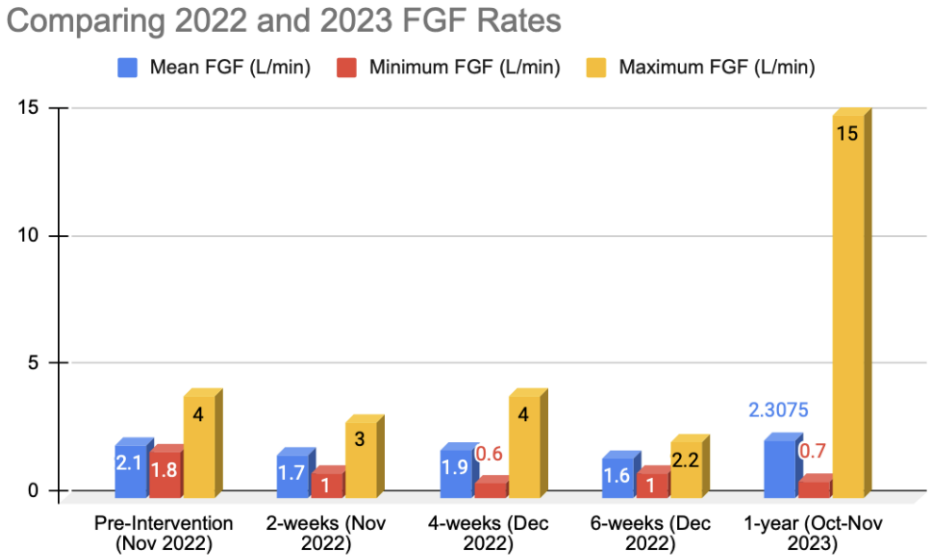
Study Population

- Study population included a convenience sample of certified registered nurse anesthetists (CRNAs) and medical doctor anesthesiologists (MDAs) involved in direct patient care.
- To ensure a comprehensive and reliable project evaluation and assessment, the same inclusion and exclusion criteria utilized by Villegas and Zarsadias were applied.
    - *Inclusion criteria:* general anesthesia cases involving laryngeal mask airway (LMA), endotracheal tube (ETT), use of Avance Cs2 of Draeger Apollo anesthesia machine, ASA I to IV patients undergoing various procedures with a duration of less than or equal to 2 hours long, sevoflurane as the sole volatile agent, and FGF utilizing oxygen, air, or a mixture of both.
    - *Exclusion criteria*: emergency cases, any case not utilizing sevoflurane, cases requiring somatosensory evoked potential (SSEP) and/or motor evoked potential (MEP) monitoring, total intravenous anesthesia (TIVA) cases, and general mask cases.

Consent, Risks, & Harms

- Participation by anesthesia providers was on a voluntary basis with no cost or compensation to the provider.
- There were no risks or harms inflicted on patients.
- Anonymity of providers was maintained due to lack of identifying factors being collected.

Results



Demographic Characteristic	n (%)
ASA	
1	7 (3.5%)
2	73 (36.5%)
3	115 (57.5%)
4	5 (2.5%)
CRNA/MD	
CRNA	133 (66.5%)
MD	67 (33.5%)
Airway Device	
ETT	141 (70.5%)
LMA	59 (29.5%)

Analysis

Descriptives

	CollectionPeriod			Statistic	Std. Error
Fresh Gas Flow Rate 10 minutes after induction	2022	Mean		1.772	.0675
		95% Confidence Interval for Mean	Lower Bound	1.638	
			Upper Bound	1.906	
		5% Trimmed Mean		1.715	
		Median		2.000	
		Variance		.410	
		Std. Deviation		.6402	
		Minimum		.6	
		Maximum		4.0	
		Range		3.4	
		Interquartile Range		.6	
		Skewness		1.236	.254
		Kurtosis		3.325	.503
	2023	Mean		2.308	.1043
		95% Confidence Interval for Mean	Lower Bound	2.102	
			Upper Bound	2.513	
		5% Trimmed Mean		2.106	
		Median		2.000	
		Variance		2.174	
		Std. Deviation		1.4744	
		Minimum		.7	
		Maximum		15.0	
		Range		14.3	
		Interquartile Range		.0	
		Skewness		4.848	.172
		Kurtosis		32.409	.342

Test Statistics[a]

	Fresh Gas Flow Rate 10 minutes after induction
Mann-Whitney U	6329.500
Wilcoxon W	10424.500
Z	-4.411
Asymp. Sig. (2-tailed)	<.001

Analysis

- The post-intervention fresh gas flow mean in 2022 was 1.7, with a standard error of 0.0675
- The 2023 mean was 2.308, with a standard error of .1043
- Although the mean FGF was higher in 2023, the medians were the same (2.00); therefore, a non-parametric test was used to determine significance.
- Mann-Whitney U test revealed a statistically significant difference between 2022 and 2023 FGF rates, p=<.001

Discussion

- Although the low flow anesthesia initiative was discussed during initial project implementation (2022), further emphasis and education on low FGF was not observed during weekly meetings during Fall 2023. Additionally, the cue cards previously installed on the anesthesia meetings were no longer present and the educational powerpoint shared with staff in 2022 had not been forwarded since its initial distribution.
- Ultimately, it appears that the adage, “out of sight, out of mind” has played a part in the lack of adherence to the previous project implementation.
    - Without continued education built into the project’s framework, Villegas and Zarsadias’s study was unable to account for this phenomenon, and new staff, RRNAs, and locum providers.

Limitations & Barriers

- We had difficulties running the exact reports needed
  - Analysis required manual extraction of the necessary data to run the reports necessary for this evaluation.
- We struggled with identifying the correct points of contact to complete Institutional Reviews and other software applications
  - If communication pathways were more clearly provided, we would have been able to get applications submitted in a timely fashion, giving us more time to collect data
- While we did collect information from 200 cases, this was only representative over a two-week span.
  - Collecting a sample over a longer period may have been able to get a more representative sample
- We were also unable to do a proper cost analysis of how the FGF observed in practice affected hospital expenditure
- We did not do any kind of “refresher” of low-flow anesthesia, perhaps this would have yielded better results.
  - Not including a content refresher, we were able to get a more accurate representation of current practice

Strengths

- **EPIC Hyperspace**
  - Allow for highly customizable reports and narrow down cases specific to what we were interested in observing
  - We were able to aggregate a larger sample of data to evaluate, eliminating the need for us to physically observe the cases being done, adding to the validity of the data collected as we were able to have a large sample size
- **CIPP framework**
  - Allowed for continuous evaluation
  - Further investigations for this project can utilize this framework by adding specific needs and goals for each aspect

Plans for Stability

- We suggest that the hospital's anesthesia department provide consistent reinforcement of this practice during the weekly meetings, with mention of the actual cost savings
- Reinforcement conducted during the meeting will also provide an opportunity to educate new staff, RRNA's, and locum providers
- Continuing to have buy-in from anesthesia faculty at the institution will also aid in compliance with low-flow anesthesia
- Having an anesthesia staff member on-site as a super-user and permanent resource can further ensure adherence to this practice change.

Recommendations

- Further recommendations for this project would be to standardize education regarding utilization of low flow anesthesia to ensure all employees are being presented with the same up-to-date information. We suggest that the hospital's anesthesia department provide consistent reinforcement of this practice during the weekly meetings, with mention of the actual cost savings. Reinforcement conducted during the meeting will also provide an opportunity to educate new staff, RRNA's, and locum providers.
- It may be beneficial to provide additional visual cues on the anesthesia machine as an added reminder. In its initial implementation, Villegas & Zarsadias utilized a sticker of a turtle to encourage employees to "slow down" on their flows (2022). Perhaps it would be useful to reinstate this practice.
- Lastly, it may be valuable to work with EPIC to have a "Best Practice Advisory" notification within the intraoperative anesthesia record to serve as another reminder to lower FGF.

Dissemination & Future Scholarship

- Plans for dissemination will include:
  - Presenting the results to the Rutgers Nurse Anesthesia Program and Graduate Nursing staff via a poster presentation.
- Program evaluation results were presented at the RWJUH anesthesia staff meeting to highlight the disparity between current FGF and the low flows observed at the conclusion of last year's project
  - This meeting provided an opportunity for current anesthesia staff to discuss current practice and potential reasons for differences in FGF
- Further practice evaluation can be done, and future students can potentially develop a root-cause analysis to further identify reasons for increases to FGF rates and any gaps in dissemination education regarding low FGF.

Conclusions

- While Villegas and Zarsadias's (2022) quality improvement project's original results demonstrated a significant reduction in FGF rates and hospital costs, project sustainability was not observed
- More frequent education may result in this practice being more diligently implemented among anesthesia providers and become a mainstay of anesthesia management at this institution
- This evaluation provides a solid framework for future improvements to this quality improvement to provide a long-lasting and sustainable change in practice

A Note from the ASA: "Statement on the Use of Low Gas Glows for Sevoflurane"

- Research concludes there is no evidence that supports a lower limit of FGF when using sevoflurane
- ASA supports low FGF when sevoflurane is being used
- NO evidence supports harm of FGF <2L/min in humans
    - Most adults can be managed with FGF of 0.5 L/min
- ASA offers a course developed by the Anesthesia Patient Safety Foundation on low-flow anesthesia which can be accessed free of charge by any anesthesia professional. Continuing education credits are offered including safety credits for those involved in the MOCA process. (See apsf.org/tei/lfa.)

References

Bilan, N., Negahdari, R., Hazrati, H., & Foroughi Moghaddam, S. (2021). Examining the quality of the competency-based evaluation program for dentistry based on the CIPP model: A mixed-method study. *Journal of dental research, dental clinics, dental prospects*, *15*(3), 203–209. https://doi.org/10.34172/joddd.2021.034

Committee on Equipment and Facilities. (2023, October 18). *Statement on the use of low gas flows for sevoflurane*. American Society of Anesthesiologists. Retrieved December 15, 2023, from https://www.asahq.org/standards-and-practice-parameters/statement-on-the-use-of-low-gas-flows-for-sevoflurane

Edmonds, A., Stambaugh, H., Pettey, S., & Daratha, K. B. (2021). Evidence-based project: Cost savings and reduction in environmental release with low-flow anesthesia. *AANA Journal, 89*(1), 27–33. https://www.aana.com/docs/default-source/aana-journal-web-documents-1/stambaugh-r.pdf?sfvrsn=5cb64df8_4

Ekbom, K., Assareh, H., Anderson, R. E., & Jakobsson, J. G. (2007). The effects of fresh gas flow on the amount of sevoflurane vaporized during 1 minimum alveolar concentration anaesthesia for day surgery: A clinical study. *Acta Anaesthesiologica Scandinavica*, *51*(3), 290–293. https://doi.org/10.1111/j.1399-6576.2006.01235.x

Kaşıkara, H., Dumanlı Özcan, A. T., Biçer, C. K., Şenat, A., Yalçın, A., Altın, C., Mustafa Aksoy, Ş., & But, A. (2022). The effect of low flow anesthesia with sevoflurane on oxidative status. *Saudi Medical Journal*, *43*(3), 227–235. https://doi.org/10.15537/smj.2022.43.3.20210876

Kennedy, R. R., French, R. A., Vesto, G., Hanrahan, J., & Page, J. (2019a). The effect of fresh gas flow during induction of anaesthesia on sevoflurane usage: A quality improvement study. *Anaesthesia*, *74*(7), 875-882. https://doi.org/10.1111/anae.14669

Kennedy, R. R., Hendrickx, J. F., & Feldman, J. M. (2019b). There are no dragons: Low-flow anaesthesia with sevoflurane is safe. *Anaesthesia and Intensive Care*, *47*(3), 223-225.https://doi.org/10.1177/0310057X19843304

Kim, C. J., Mo, H., & Lee, J. Y. (2022). Evaluation of an ultrasound program in nationwide Continuing Professional Development (CPD) in Korean public health and medical institutions. *BMC medical education*, *22*(1), 261. https://doi.org/10.1186/s12909-022-03271-4

References

Lineburger, E., Módolo, N., Braz, L., & do Nascimento, P. (2023). Minimal fresh gas flow sevoflurane anesthesia and postoperative acute kidney injury in on-pump cardiac surgery: A randomized comparative trial. *Brazilian Journal of Anesthesiology (English Edition)*, *73*(1), 46–53. https://doi.org/10.1016/j.bjane.2021.11.004

Sondekoppam, R. V., Narsingani, K. H., Schimmel, T. A., McConnell, B. M., Buro, K., & Özelsel, T. J.-P. (2020). The impact of sevoflurane anesthesia on postoperative renal function: A systematic review and meta-analysis of randomized-controlled trials. *Canadian Journal of Anesthesia, 67*(11), 1595–1623.

Toosi, M., Modarres, M., Amini, M., & Geranmayeh, M. (2021). Context, Input, Process, and Product Evaluation Model in medical education: A systematic review. *Journal of education and health promotion*, *10*(1), 199. https://doi.org/10.4103/jehp.jehp_1115_20

RUTGERS
School of Nursing

Thank you for your time!