Mitigating the environmental impacts of anesthetic gases in healthcare

Executive Summary

Prepared by: Alpamys Issanov, UBC Sustainability Scholar, 2022
Prepared for: Emily Lomax, Sustainability Consultant, Energy & Environmental Sustainability Team, Vancouver Coastal Health

August 2022

Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organisations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Vancouver Coastal Health staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Vancouver Coastal Health, Fraser Health, Providence Health Care, Provincial Health Services Authority, or the University of British Columbia.

Acknowledgements

The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations.

The author would like to thank all of the staff of the Energy and Environmental Sustainability team, the hospital pharmacies within Vancouver Coastal Health, Fraser Health, Providence Health Care, and Provincial Health Services Authority, and all interviewees who graciously offered their feedback and time.

Cover photo by Akram Huseyn on Unsplash

Introduction

The purpose of this research project was to explore existing anesthetic gas emissions reduction initiatives, to understand contributions of anesthetic gas emissions across four health organizations in British Columbia, and to prioritize the action needed to reduce their impact. Using purchasing pharmacy data, the author illustrated temporal trends in anesthetic gas use and determined the anesthetic gas with the greatest contribution to carbon emissions. Building on interviews with anesthesiologists and an extensive literature review, the project describes existing challenges, opportunities, and best practices in implementing anesthetic gas reduction initiatives in the four health organizations and worldwide. The report concludes by noting the importance of regularly collecting data, educating anesthesia stakeholders, setting goal and schedules to implement reduction initiatives, tracking progress, and developing a communication plan. This report aims to serve as an informational document for the Energy and Environmental Sustainability Team within Vancouver Coastal Health to support and empower anesthesiologists, healthcare workers interested in reducing the carbon footprints of inhalational anesthetic gases and leadership to actively engage in anesthetic gas reduction initiatives.

Background

Globally, the healthcare industry is responsible for 5% greenhouse emissions (4.6% in Canada). According to the latest estimates, the contribution of inhalational anesthetic gases (IAG) to healthcare carbon footprint is approximately 5%-9% in acute care settings and more than half in hospital operating rooms. There are three commonly used volatile anesthetic agents in hospital settings – desflurane, sevoflurane and isoflurane. Desflurane has the highest heat trapping effect and global warming potential. Overall, the contribution of the anesthetic gases is not well understood, as most health organizations in Canada and worldwide do not report data on use of anesthetic gases. The greenhouse gas contribution of IAG is not currently regulated and reported under the Kigali Amendment of the Montreal protocol, the Kyoto Protocol, the Paris Agreement, British Columbia greenhouse gas inventory, and Canada's greenhouse gas inventory. There is also insufficient literature on anesthetic reduction initiatives in health organizations across British Columbia.

The objectives of this research project were to understand anesthetic gas emissions and identify current anesthetic gas emissions reduction initiatives across four health organizations in British Columbia: Fraser Health, Providence Health Care (Providence), Provincial Health Services Authority (PHSA), Vancouver Coastal Health (VCH); in addition, to conduct a literature review of best practices for anesthetic gas reporting methodologies used in different health organizations worldwide. The findings from this research project aim to support the Energy and Environmental Sustainability team to engage, empower and expand anesthetic gas emissions reduction initiatives in the four focus health organizations and across B.C.

Research Approach

Annual data on purchased amount of IAG between 2010 and 2021 were collected from hospital pharmacies in the four focus health organizations. Anesthetic gas volumes were transformed to carbon dioxide equivalent emissions. The quantitative data were summarized and visualized using R statistical software. Qualitative data were collected by conducting semi-structured interviews with health anesthesiologists. Interviewees shared their experiences in reducing carbon footprints of IAG and identified commonly encountered challenges and opportunities in implementing and expanding reduction initiatives.

Summary

The research findings showed that the purchased volumes of desflurane are declining in Fraser Health and Providence. The decline in desflurane use had financial benefits in cost savings in Fraser Health and Providence. Providence had **substantial cost savings since 2011**. The **decrease in desflurane use also resulted in significant reductions (78%-88%)** in carbon dioxide equivalent emissions in Fraser Health and Providence. Although incomplete data was presented for PHSA and VCH, some individual hospital data within these health organizations showed similar trends in reduction of desflurane use and its emissions.

Results from interviewees suggested that similar reduction initiatives are underway or implemented to reduce or eliminate desflurane across their health organizations, and the health organizations are considering other alternative environmentally sustainable anesthesia techniques. Interviewees identified the following challenges in implementing reduction initiatives – **the reluctance or unwillingness of anesthesiologists to change their practices** to more environmentally sustainable practices, **a lack of awareness** of the significant environmental impact of IAG, **dilemma of whether desflurane is a superior or equivalent anesthetic gas** to sevoflurane, specialized **equipment** (e.g. target control infusion pumps) **is unavailable** to change anesthesia practices and **low interest from leadership** to implement reduction initiatives.

Several opportunities were also shared by interviewees to address these challenges:

Education. Awareness was considered the key to successfully implementing reduction initiatives. Anesthesiologists, surgical medical workers, medical residents, and anesthesia assistants were considered important target populations to educate.

Data collection: Since data plays a key role in implementing initiatives, especially in understanding and monitoring carbon emissions from IAG, interviewees recommended collecting data systematically and on a regular basis.

Publicizing: Disseminating data and findings through health organization newsletters or a specific platform would provide a better understanding and tracking their performances in terms of carbon footprints of IAG and encourage competition on individual or group levels.

Research: Several quality improvement or research projects were suggested by the interviewees.

Further actions: All interviewees strongly recommended banning and removing desflurane from purchasing lists and formulary. After banning desflurane, interviewees suggested to implement practices of low fresh gas flow rates with sevoflurane, and then gradually move from sevoflurane use to total intravenous anesthesia which does not require anesthetic gases.

Recommendations

Based on the results of analyzing the quantitative data of IAG, summarizing qualitative interview data, and a comprehensive literature review of existing international environmentally sustainable anesthesia practices worldwide recommendations were developed. These recommendations will empower and inspire health organizations and healthcare workers to reconsider and transform their anesthesia practices and implement environmentally conscious anesthesia techniques.

1. Identify and support anesthesia champions

In the first step, it is important to identify individual(s) within a department or hospital **who are interested in transforming or have already transformed their practices** to environmentally conscious anesthesia. They should also be interested in educating their colleagues and sharing their experience with other healthcare workers. Motivated anesthesiologists can start teaching anesthesiologists, anesthesia assistants, nurses, surgeons, and other interested stakeholders about the environmental impact of IAG.

2. Identify key stakeholders and form a project team

A department or hospital leader should support forming a multidisciplinary project team to reduce IAG emissions. Although anesthesiologists are responsible for choosing an anesthetic agent and anesthetic technique, **anesthesia assistants can be effective in implementing changes** to current anesthesia practices (e.g. taking away desflurane from an anesthesia machine). Pharmacy workers should be involved to continuously track and gather feedback data on IAG use. Also, having representatives of anesthesia machine manufacturers may be useful in systematically retrieving and reporting IAG use data from anesthetic machines.

3. Data collection

To understand the carbon footprint of IAG, historical and continuous anesthetic usage data should be collected. This data will help to establish **baseline GHG emissions** from IAG and to identify next steps to reduce the emissions. It is also important to collect supplementary data (e.g. anesthesia or surgical data) to normalize data for benchmarking purposes.

4. Set goals and timelines

The project team should set achievable anesthetic gas reduction goals and determine an appropriate timeline to accomplish them. For example, eliminating desflurane from anesthesia practice could result in 96% emissions reduction. After achieving a certain goal, the project team should focus on achieving the next anesthetic gas reduction goal.

5. Identify and implement reduction strategies

The project team should, first, focus on high-impact reduction opportunities. Anesthesiologists should avoid using IAG with disproportionally high climate impacts, and instead choose environmentally sustainable anesthetic gases with the lowest global warming potential (e.g. sevoflurane before isoflurane, preference to isoflurane over desflurane). It is important that providers agree to limit desflurane to only specific agreed cases or better to **eliminate desflurane from a facility formulary**. Next, anesthesiologists should be encouraged to use **low fresh gas flow rate** during sedation and general anesthesia. **Total intravenous anesthesia or total-regional anesthesia** can be another alternative reduction strategy to be implemented. **Capturing and recycling waste IAG** through an active scavenging system should be considered when redesigning or renovating an operating room or healthcare facility.

6. Track progress

It is essential to monitor and evaluate the progress of carbon reduction initiatives. There are multiple freely available calculators to estimate the environmental impact and costs associated with anaesthesia. Tracking performance over time can be done through simple **audits or quality improvement programmes** of volumes of purchased IAG within a facility.

7. Develop a communication plan & recognition

Sharing the results of the initiatives will encourage and engage in continuing environmental conscious practice improvements. Anesthetic gas reduction initiatives' outcomes and gained **experience should be disseminated** through grand rounds, anaesthetic professional societies, professional development, professional networking, conferences, newsletters, and publications. Finally, **recognizing and rewarding champions** in reducing anesthetic gas emissions should be supported by leadership in form of sharing and celebrating success stories, and honouring achievements as awards and grants.

References

Abraham, C., & Sheeran, P. (2015). The health belief model. *Predicting health behaviour: Research and practice with social cognition models*, *2*, 30-55.

Alexander, R., Poznikoff, A., & Malherbe, S. (2018). Greenhouse gases: the choice of volatile anesthetic does matter. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *65*(2), 221-222.

American Society of Anesthesiologists. (2017). *Greening the operating room and perioperative arena: environmental sustainability for anesthesia practice*. https://www.asahq.org/about-asa/governance-and-committees/asa-committees/environmental-sustainability/greening-the-operating-room

American Society of Anesthesiologists. (2022). *Inhaled Anesthetic 2022 Challenge*. Retrieved August 2, 2022 from https://www.asahq.org/about-asa/governance-and-committees/asa-committees/environmental-sustainability/inhaled-anesthetic-challenge

Andersen, M. P. S., Nielsen, O. J., Wallington, T. J., Karpichev, B., & Sander, S. P. (2012). Assessing the impact on global climate from general anesthetic gases. *Anesthesia & Analgesia*, *114*(5), 1081-1085.

Arain, S. R., Barth, C. D., Shankar, H., & Ebert, T. J. (2005). Choice of volatile anesthetic for the morbidly obese patient: sevoflurane or desflurane. *Journal of clinical anesthesia*, *17*(6), 413-419.

Ard, J. L., Tobin, K., Huncke, T., Kline, R., Ryan, S. M., & Bell, C. (2016). A survey of the American Society of Anesthesiologists regarding environmental attitudes, knowledge, and organization. *A & A case reports*, *6*(7), 208-216.

ASo, A. (2014). ASA physical status classification system. *ASA House of Delegates*.

Association of Anaesthetists. *Anaesthetic gases calculator*. Retrieved July 29, 2022 from https://anaesthetists.org/Home/Resources-publications/Environment/Guide-to-green-anaesthesia/Anaesthetic-gases-calculator

Campbell, M., & Pierce, J. T. (2015). Atmospheric science, anaesthesia, and the environment. *BJA Education*, *15*(4), 173-179.

Casale, T., Caciari, T., Rosati, M. V., Gioffrè, P. A., Schifano, M. P., Capozzella, A., . . . Tomei, F. (2014). Anesthetic gases and occupationally exposed workers. *Environmental toxicology and pharmacology*, *37*(1), 267-274.

Charlesworth, M., & Swinton, F. (2017). Anaesthetic gases, climate change, and sustainable practice. *The Lancet Planetary Health*, *1*(6), e216-e217.

Chen, G., Zhou, Y., Shi, Q., & Zhou, H. (2015). Comparison of early recovery and cognitive function after desflurane and sevoflurane anaesthesia in elderly patients: A meta-analysis of randomized controlled trials. *Journal of International Medical Research*, *43*(5), 619-628.

Cox, R. G. (2011). Smith's Anesthesia for Infants and Children. In: Springer.

de Vos, M., & Alexander, R. BC anesthesiologists reduce carbon footprint by choosing wisely.

Devlin-Hegedus, J., McGain, F., Harris, R., & Sherman, J. (2022). Action guidance for addressing pollution from inhalational anaesthetics. *Anaesthesia*.

Edmonds, A. (2021). Evidence-Based Project: Cost Savings and Reduction in Environmental Release With Low-Flow Anesthesia. *AANA journal*, *89*(1).

European Environment Agency. Retrieved July 13, 2022 from http://www.eea.europa.eu/

Gan, T. J., Belani, K. G., Bergese, S., Chung, F., Diemunsch, P., Habib, A. S., . . . Urman, R. D. (2019). Fourth consensus guidelines for the management of postoperative nausea and vomiting. *Anesthesia & Analgesia*, *131*(2), 411-448.

Gentz, B. A., & Malan, T. P. (2001). Renal toxicity with sevoflurane. *Drugs*, *61*(15), 2155-2162.

Golembiewski, J. (2010). Economic considerations in the use of inhaled anesthetic agents. *American Journal of Health-System Pharmacy*, *67*(8_Supplement_4), S9-S12.

Greener Anaesthesia and Sustainability Project. (2022). *GASP - Greener Anaesthesia & Sustainability Project*. Retrieved August 2, 2022 from https://networks.sustainablehealthcare.org.uk/networks/sustainable-operating-theatres/gasp-greener-anaesthesia-sustainability-project

Hanna, M., & Bryson, G. L. (2019). A long way to go: minimizing the carbon footprint from anesthetic gases. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *66*(7), 838-839.

Hudson, A. E., Herold, K. F., & Hemmings Jr, H. C. (2019). Pharmacology of inhaled anesthetics. In *Pharmacology and physiology for anesthesia* (pp. 217-240). Elsevier.

Ishizawa, Y. (2011). General anesthetic gases and the global environment. *Anesthesia & Analgesia*, *112*(1), 213-217.

Kennedy, R. R., Hendrickx, J. F., & Feldman, J. M. (2019). There are no dragons: low-flow anaesthesia with sevoflurane is safe. In (Vol. 47, pp. 223-225): SAGE Publications Sage UK: London, England.

Lenzen, M., Malik, A., Li, M., Fry, J., Weisz, H., Pichler, P.-P., . . . Pencheon, D. (2020). The environmental footprint of health care: a global assessment. *The Lancet Planetary Health*, *4*(7), e271-e279.

Lubarsky, D. A., French, M. T., Gitlow, H. S., Rosen, L. F., & Ullmann, S. G. (2019). Why money alone can't (always)"nudge" physicians: the role of behavioral economics in the design of physician incentives. *Anesthesiology*, *130*(1), 154-170.

Macario, A., Dexter, F., & Lubarsky, D. (2005). Meta-analysis of trials comparing postoperative recovery after anesthesia with sevoflurane or desflurane. *American journal of health-system pharmacy*, *62*(1), 63-68.

MacNeill, A. J., Lillywhite, R., & Brown, C. J. (2017). The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. *The Lancet Planetary Health*, *1*(9), e381-e388.

Martindale, T. G. (2016). The CO2e of inhalational anaesthetic use in a University Hospital; suggestions for continued progressive reductions. *BJA: British Journal of Anaesthesia*, *117*(eLetters Supplement).

McGain, F., Sheridan, N., Wickramarachchi, K., Yates, S., Chan, B., & McAlister, S. (2021). Carbon footprint of general, regional, and combined anesthesia for total knee replacements. *Anesthesiology*, *135*(6), 976-991.

McGain, F., White, S., Mossenson, S., Kayak, E., & Story, D. (2012). A survey of anesthesiologists' views of operating room recycling. *Anesthesia & Analgesia*, *114*(5), 1049-1054.

Myles, P. S., Leslie, K., Peyton, P., Paech, M., Forbes, A., Chan, M. T., . . . Wallace, S. (2009). Nitrous oxide and perioperative cardiac morbidity (ENIGMA-II) Trial: rationale and design. *Am Heart J*, *157*(3), 488-494.e481. https://doi.org/10.1016/j.ahj.2008.11.015

National Clinical Guideline Centre. (2010). *Sedation in children and young people*. Retrieved August 2, 2022 from https://www.nice.org.uk/guidance/cg112/evidence/full-guideline-136287325

National Institute for Health and Care Excellence. (2019). *Intrapartum care for women with existing medical conditions or obstetric complications and their babies*. Retrieved August 2, 2022 from https://www.nice.org.uk/guidance/ng121

NHS England. (2022). *Delivering a net zero NHS*. Retrieved August 3, 2022 from https://www.england.nhs.uk/greenernhs/publication/delivering-a-net-zero-national-health-service/

Petre, M.-A., Bahrey, L., Levine, M., van Rensburg, A., Crawford, M., & Matava, C. (2019). A national survey on attitudes and barriers on recycling and environmental sustainability efforts among Canadian anesthesiologists: an opportunity for knowledge translation. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *66*(3), 272-286.

Petre, M.-A., Bahrey, L., Levine, M., van Rensburg, A., Crawford, M., & Matava, C. T. (2020). Anesthesia environmental sustainability programs—a survey of Canadian department chiefs and residency program directors. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *67*(9), 1190-1200.

Practice Greenhealth. *Anesthetic gas how-to guide. A guide to climate-smart anesthesia care.* Retrieved July 13, 2022 from https://practicegreenhealth.org/sites/default/files/2019-04/anesthetic_gas_how-to.pdf

Richter, H., Weixler, S., & Schuster, M. (2020). Der CO2-Fußabdruck der Anästhesie. *Anasth Intensivmed*, *67*, 154-161.

Royal College of Anaesthetists. *The Anaesthetic Impact Calculator*. https://www.rcoa.ac.uk/about-college/strategy-vision/environment-sustainability/anaesthetic-impact-calculator

Ryan, S. M., & Nielsen, C. J. (2010). Global warming potential of inhaled anesthetics: application to clinical use. *Anesthesia & Analgesia*, *111*(1), 92-98.

Seglenieks, R., Wong, A., Pearson, F., & McGain, F. (2022). Discrepancy between procurement and clinical use of nitrous oxide: waste not, want not. *British Journal of Anaesthesia*, *128*(1), e32-e34.

Sherman, J., Le, C., Lamers, V., & Eckelman, M. (2012). Life cycle greenhouse gas emissions of anesthetic drugs. *Anesthesia & Analgesia*, *114*(5), 1086-1090.

Sherman, J. D., & Ryan, S. (2010). Ecological responsibility in anesthesia practice. *International anesthesiology clinics*, *48*(3), 139-151.

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/Journal canadien d'anesthésie*, *67*(11), 1595-1623.

Strum, E. M., Szenohradszki, J., Kaufman, W. A., Anthone, G. J., Manz, I. L., & Lumb, P. D. (2004). Emergence and recovery characteristics of desflurane versus sevoflurane in morbidly obese adult surgical patients: a prospective, randomized study. *Anesthesia & Analgesia*, *99*(6), 1848-1853.

Trainee-Led Research and Audit in Anaesthesia for Sustainable Healthcare. (2022). *TRA2SH. Quality improvement.* Retrieved August 2, 2022 from https://www.tra2sh.org

Traynor, K. (2009). Inhaled anesthetics present cost-saving opportunity. *American Journal of Health-System Pharmacy*, *66*(7), 606-608.

U.S. Food and Drug Administration. (2003). *ULTANE® (sevoflurane) volatile liquid for inhalation*. Retrieved August 3, 2022 from https://www.accessdata.fda.gov/drugsatfda_docs/label/2006/020478s016lbl.pdf

United Nations Kyoto Protocol. Retrieved July 13, 2022 from http://unfccc.int/resource/docs/cop3/07a01.pdf#page=31

United States Environmental Protection Agency. Retrieved July 13, 2022 from https://www.epa.gov/climate-change

Vaĭsman, A. (1967). Working conditions in the operating room and their effect on the health of anesthetists. *Eksperimental'naia khirurgiia i anesteziologiia*, *12*(3), 44-49.

Vogel, L. (2019). Canada's health system is among the least green. In *Cmaj* (Vol. 191, pp. E1342-e1343). https://doi.org/10.1503/cmaj.1095834

Vollmer, M. K., Rhee, T. S., Rigby, M., Hofstetter, D., Hill, M., Schoenenberger, F., & Reimann, S. (2015). Modern inhalation anesthetics: Potent greenhouse gases in the global atmosphere. *Geophysical Research Letters*, *42*(5), 1606-1611.

Wallington, T., Anderson, J., Mueller, S., Winkler, S., Ginder, J., & Nielsen, O. (2011). Time horizons for transport climate impact assessments. *Environmental science & technology*, *45*(7), 3169-3170.

Walts, L. F., Forsythe, A. B., & Moore, J. G. (1975). Critique: occupational disease among operating room personnel. *The Journal of the American Society of Anesthesiologists*, *42*(5), 608-610.

White, S., Shelton, C., Gelb, A., Lawson, C., McGain, F., Muret, J., . . . Anaesthesia, r. t. W. F. o. S. o. A. G. W. G. o. E. S. i. (2022). Principles of environmentally-sustainable anaesthesia: a global consensus statement from the World Federation of Societies of Anaesthesiologists. *Anaesthesia*, *77*(2), 201-212.

Yale University. (2022). *Yale Inhaled Anesthesia Climate Initiative: Project Drawdown Inhaled Anesthetic 2020 Challenge*. https://ysph.yale.edu/yale-center-on-climate-change-and-health/healthcare-sustainability-and-public-health/project-drawdown/

Zuegge, K. L., Bunsen, S. K., Volz, L. M., Stromich, A. K., Ward, R. C., King, A. R., . . . Steiner, R. P. (2019). Provider education and vaporizer labeling lead to reduced anesthetic agent purchasing with cost savings and reduced greenhouse gas emissions. *Anesthesia & Analgesia*, *128*(6), e97-e99.

Özelsel, T. J.-P., Sondekoppam, R. V., & Buro, K. (2019). The future is now—it's time to rethink the application of the Global Warming Potential to anesthesia. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, *66*(11), 1291-1295.