BC anesthesiologists reduce carbon footprint by choosing wisely

Trends of volatile anesthetic use in three health authorities across BC.

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ABSTRACT: Anesthesiologists are well positioned to reduce the anesthetic-related carbon footprint by reconsidering their use of volatile anesthetics. Across BC, the environmental impact of these medically necessary greenhouse gases is not well documented. In this study, we identify the trends of volatile anesthetic use and the associated annual carbon footprints in three health authorities across BC from 2013 to 2019. Each health authority has reduced desflurane use, resulting in a 61%, 53%, and 63% reduction in the carbon footprint per operation performed in the Vancouver Island Health Authority, Interior Health Authority, and Northern Health Authority, respectively. Across the province, this equates to a difference of 8.8 million kg of CO_2 released into the atmosphere in 2013 compared to 2019. By increasing awareness about how individual practice patterns can affect greenhouse gas emissions, we hope to influence more sustainable practices across BC.

Introduction

Climate change is a considerable threat to human health on a global scale.[1] The medical community has an obligation to advocate for change and to reduce its environmental impact, while simultaneously maintaining the current standard of patient care. Volatile anesthetics are documented to contribute 5% of the carbon footprint in the acute medical setting.[2] Consequently, anesthesiologists have the opportunity and responsibility to contribute to a more sustainable future by evaluating the environmental impact of their clinical practice.

Volatile anesthetics are classified as halogenated fluorocarbons and are known to be potent greenhouse gases. However, not all greenhouse gases are equal. Their potency depends on the atmospheric lifetime, total radiation absorbed, and concentration of compounds in the atmosphere that absorb the same wavelength of radiation.[3] The impact that an individual gas will have on global warming over a specific time frame can be quantified by its global warming potential (GWP). The GWP is a weight-based equivalency measure used to compare a compound's environmental impact to that of carbon dioxide (CO_2).[3] The greenhouse gas emissions or carbon footprint of each volatile anesthetic can be quantified from the GWP and volume of gas used and expressed as the carbon dioxide equivalent (CDE).[4]

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In 2014, the American Society of Anesthesiologists Environment Sustainability Task Force published actions that anesthesiologists can take to reduce their carbon footprint in the operating room.[5] These include choosing a volatile anesthetic with a lower GWP and minimizing fresh gas flow.[5] The GWPs over 20 years (GWP_{20}) for commonly used volatile anesthetic agents are 6810, 1800, and 440 for desflurane, sevoflurane, and isoflurane, respectively.[6] When accounting for anesthetic potency and flow rates, desflurane has a twenty-six-fold and thirteenfold larger environmental impact than sevoflurane and isoflurane if used in large quantities.[7]

In the Vancouver Island Health Authority, joint efforts between the Department of Anesthesiology and the Sustainability Office resulted in the purchase of low-flow anesthetic machines in 2015 and changes to practice patterns to preferentially use sevoflurane over desflurane. Previous work has investigated the impact of similar sustainability measures in Vancouver hospitals[8] and compared greenhouse gas emissions from Vancouver General Hospital to two international facilities.[9] However, trends of anesthetic-related emission rates in the Vancouver Island Health Authority and British Columbia as a whole remain undocumented in the literature. We know that the collection of data to inform the environmental impact of clinical practice and the success of sustainability measures is essential for continued quality improvement.[7] Therefore, we initiated a project to update our understanding of anesthetic-related greenhouse gas emissions in the Vancouver Island Health Authority and across comparable health authorities in British Columbia.

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Methods

This project was identified as a quality assurance project and did not require research ethics board review (Tri-Council Policy Statement 2 Article 2.5). Environmental and sustainability offices in each participating health authority were contacted to obtain consent and access to anesthetic gas–purchasing data from 2013 to 2019. Participating health authorities were the Vancouver Island Health Authority (VIHA), the Interior Health Authority (IHA), and the Northern Health Authority (NHA).

Volumes of volatile anesthetic agents were provided by pharmacy services for 9 VIHA hospitals, 13 IHA hospitals, and 10 NHA hospitals. The annual carbon dioxide equivalent over 20 years (CDE_{20}) for each health authority was calculated using purchasing data and GWP_{20} values previously reported by Anderson and colleagues.[6] To allow for direct comparison between the participating health authorities, the calculated CDE_{20} was then standardized by the number of operations performed in each health authority using data from the BC Surgical Patient Registry.

Results

Data from the three participating health authorities demonstrate that anesthesiologists are reducing their use of desflurane and subsequently reducing their carbon footprint over time. In the VIHA, there was a 60% decrease in desflurane use to 234 L per year in 2019 from 583 L per year in 2013 **[Table 1]**. This was associated with a 3% increase in sevoflurane use to 446 L from 433 L per year over the same time period, resulting in sevoflurane surpassing desflurane volumes in 2015 **[Figure 1A]**. Similar results were obtained from the IHA during this period, with a 53% reduction in desflurane use to 418 L from 881 L per year. This was associated with a 33% increase in sevoflurane use to 493 L from 371 L per year, with desflurane use remaining higher than sevoflurane until 2018 **[Figure 1B]**. In comparison, the NHA anesthesiology departments have consistently used sevoflurane in higher quantities than desflurane since 2013. Also, in the NHA, desflurane and sevoflurane use has decreased by 53% (to 55 L from 118 L per year) and 46% (to 225 L from 414 L per year), respectively **[Figure 1C]**. Across the

TABLE 1. Volumes of volatile anesthetics purchased by participating health authorities between 2013 and 2019.

	Volume of sevoflurane (L/year)			Volume of desflurane (L/year)		
Year	VIHA	IHA	NHA	VIHA	IHA	NHA
2013	433	371	414	583	881	118
2014	455	307	349	513	647	130
2015	415	436	306	322	784	114
2016	402	446	335	318	675	89
2017	401	451	263	287	560	114
2018	450	470	239	264	489	55
2019	446	493	225	234	418	55

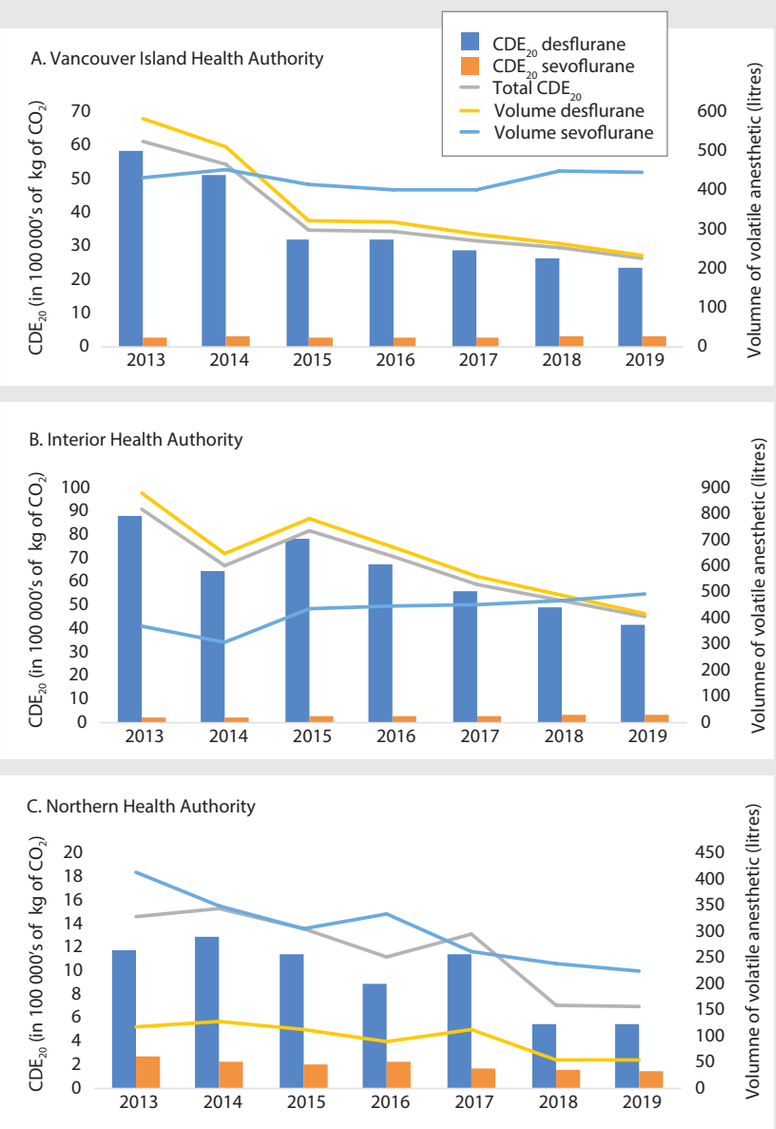

FIGURE 1. Trends of volatile anesthetic use for VIHA (A), IHA (B), and NHA (C), and corresponding carbon footprint or CDE_{20} expressed in 100 000's of kg of CO_2.

three health authorities, these changes resulted in a decrease of 8 807 573 kg of CO_2 produced between 2013 and 2019.

To effectively compare the three health authorities, the calculated CDE_{20} values were standardized by the number of operations performed in each **[Figure 2]**. With the reduction in desflurane use, the VIHA saw a 61% drop in its carbon footprint to 40 kg of CO_2 from 102 kg per operation between 2013 and 2019. In comparison, the CDE_{20} per operation for the IHA decreased to 75 kg of CO_2 in 2019 from 161 kg of CO_2 in 2013, a 53% change. In the NHA, there was an overall reduction in the carbon footprint per operation of 63%, to 34 kg of CO_2 in 2019 from 93 kg of CO_2 in 2013. Across the province, these efforts resulted in the cumulative carbon footprint decreasing by 58%, which is equivalent to 208 kg of CO_2 per operation **[Table 2]**.

Discussion

Anesthesiology departments have been called on to reduce their anesthetic-related greenhouse gas emissions.[8] Monitoring and understanding emission rates and trends in local health authorities is essential to recognize success in environmental initiatives and identify areas for improvement.[7] Two studies have examined the environmental impact of surgical suite operations in Vancouver, providing valuable insight into the benefits of preferentially using volatile anesthetics with a lower GWP_{20} over desflurane, and the use of low-flow anesthetic machines.[8,9] In response to these environmental initiatives, Alexander and colleagues reported a 66% reduction in the carbon footprint of volatile anesthetics in eight Vancouver hospitals between 2012 and 2016.[8] Additionally, desflurane use at Vancouver General Hospital has been found to increase emissions rates tenfold when compared to a British facility that eliminated the use of desflurane.[9] However, this is the first study to quantify the anesthetic-related environmental impact outside the Greater Vancouver area.

Our data show that anesthesiologists across BC are reducing the use of desflurane. In response, IHA and to a lesser extent VIHA are increasing the use of sevoflurane, while the NHA has seen a concurrent reduction of sevoflurane use. Due to the disproportionate environmental impact of desflurane compared to sevoflurane, these changes have resulted in a reduction in each health authority's carbon footprint of more than 50%. Additionally, the installation of low-flow anesthetic machines in the VIHA was associated with a 36% reduction in CDE_{20} in 2015, the largest annual reduction across the province. Across the province, these sustainability measures have resulted in a cumulative reduction of the anesthetic-related carbon footprint over 7 years, equivalent to removing 7476 vehicles from use.[10]

These results support existing literature, which states that judicious use of desflurane in anesthetic practice[4,5] and encouraging the use of low-flow anesthetic techniques[11,12] are effective for reducing the anesthesia-related carbon footprint. However, various other avenues for minimizing the impact of anesthetic gases have been proposed. At the bedside, the use of properly sized equipment for mask ventilation, laryngeal mask airways, and endotracheal tubes, as well as managing leaks in the system, can reduce excessive use of volatile anesthetics.[13] Additionally, the movement toward environmentally inert gases offers a solution to the dichotomy between health necessity and the adverse environmental impact of anesthetic gases. Xenon, a noble gas found to be an effective anesthetic,[14] has shown promise, but its use is not currently economically feasible.[3,12] System-wide, the installation of volatile anesthetic recovery systems could reduce emission rates.[15] Typically, less than 5% of the volatile anesthetics used are metabolized by the patient, with the remainder released into the atmosphere. Scavenging systems that collect waste gases have been used to minimize health care practitioners' exposure to anesthetic agents in the operating room, but they do not reduce environmental emisions.[7] However,

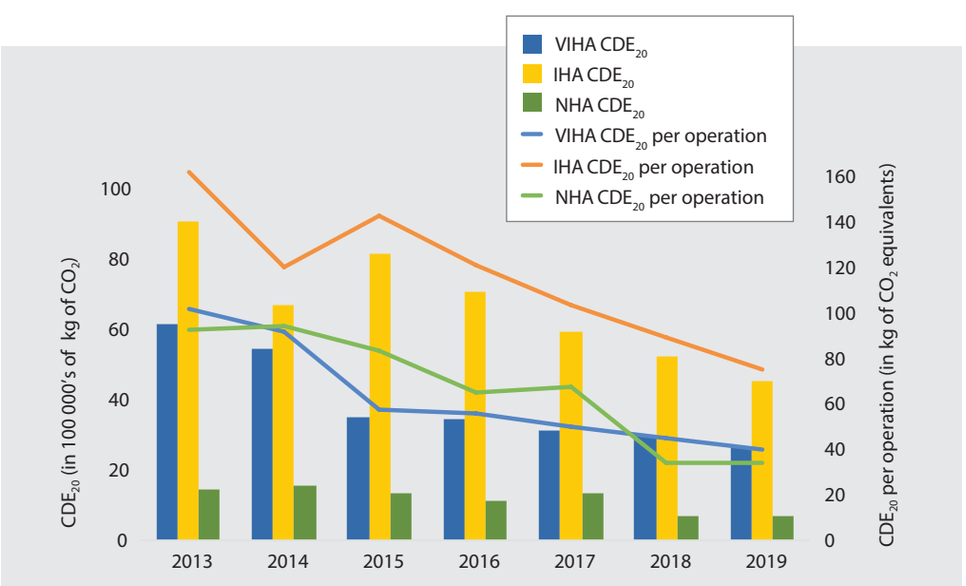

FIGURE 2. Standardized CDE_{20} per operation in each health authority from 2013-2019.

TABLE 2. Change in CDE_{20} (expressed as kg of CO_2 per operation) between 2013 and 2019.

	VIHA	IHA	NHA	Total
CDE_{20} per operation, 2013	102 kg CO_2	161 kg CO_2	93 kg CO_2	356 kg CO_2
CDE_{20} per operation, 2019	40 kg CO_2	75 kg CO_2	34 kg CO_2	148 kg CO_2
Absolute reduction	62 kg CO_2	86 kg CO_2	59 kg CO_2	208 kg CO_2
Relative difference	61%	53%	63%	58%

technologies that process waste gases into inert compounds or recycle gases for reuse provide an avenue for greening anesthetic operations.[15] In Canada, the Deltasorb and Centralsorb systems developed by Blue-Zone Technologies Ltd. are silica zeolite absorption systems that capture waste gases.[15,16] In contrast to other recovery systems, Blue-Zone facilities have the manufacturing technology available and approval from Health Canada to recycle captured gases for reuse.[16,17]

A lack of awareness about anesthetic-related greenhouse gas emissions and the available environmental measures are significant barriers to building sustainable practices.[7,18] By improving the understanding of anesthetic-related greenhouse gas emissions across BC, it is our hope to influence change across health authorities and individual practising anesthesiologists. ■

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Due to the disproportionate environmental impact of desflurane compared to sevoflurane, these changes have resulted in a reduction in each health authority's carbon footprint of more than 50%.

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