DOI: https://doi.org/10.11144/Javeriana.umed66.aima

Inhaled Anesthetics and the Environment: Carbon Footprint of a Colombian High-Complexity Hospital

Anestésicos inhalados y medio ambiente: huella de carbono en un hospital de alta complejidad colombiano

Received: 08 july 2024 | Accepted: 09 november 2024

Reinaldo Grueso Angulo
Hospital Universitario San Ignacio-Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0000-0001-7777-6630
Silvia Helena Galvis Navarrete[a]
Hospital Universitario San Ignacio-Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0000-0001-5529-8279
Valeria Ojeda Silva
Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0009-0007-6491-2008
Ana María Cárdenas
Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0000-0002-0228-4305
Natalia Saade Cleves
Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0000-0001-8184-5264
Juan Diego Serrano Rivera
Pontificia Universidad Javeriana, Bogotá, Colombia
ORCID: https://orcid.org/0000-0002-9208-8016
Stela del Pilar Baracaldo Gómez
Hospital Universitario San Ignacio, Bogotá, Colombia
ORCID: https://orcid.org/0000-0003-1417-0281

[a]**Corresponding Author:** silvia.galvis@javeriana.edu.co

How to cite: Grueso Angulo R, Galvis Navarrete SH, Ojeda Silva V, Cárdenas AM, Saade Cleves N, Serrano Rivera JD, Baracaldo Gómez SdelP, Inhaled Anesthetics and the Environment: Carbon Footprint of a Colombian High-Complexity Hospital. *Univ Med. 2025;66.* https://doi.org/10.11144/Javeriana.umed66.aima

ABSTRACT

Introduction: This article illustrates how inhaled anesthetics (sevoflurane and desflurane) are used within the routine practice of anesthesiologists in the operating rooms of a high-complexity hospital, as well as their environmental repercussions and the consequences they produce. The relevance of this information lies in the carbon footprint of inhaled anesthetics, particularly their greenhouse gas emissions, which is an increasing concern. **Objectives:** To evaluate the frequency of sevoflurane and desflurane use in anesthetic practice and to analyze anesthesiologists' perceptions of their environmental impact and cost. **Methodology:** A retrospective descriptive study based on an electronic survey administered via REDCap. Participation was voluntary and included 40 anesthesiologists, who provided information on their practices related to the administration and disposal of inhaled anesthetics. **Results:** Sevoflurane is used approximately 10 times more frequently than desflurane, primarily due to its lower environmental impact and reduced cost to the healthcare system. Furthermore, there was growing awareness among anesthesiologists regarding environmental sustainability and the

need for strategies to reduce greenhouse gas emissions. **Conclusions:** The study reflects a clear preference for sevoflurane, driven by its lower carbon footprint and cost. It is essential to promote strategies that optimize the use of inhaled anesthetics and reduce their environmental impact in high-complexity hospitals.

Keywords
sevoflurane; desflurane; carbon footprint; greenhouse effect; human ecology.

RESUMEN
Introducción: Este artículo muestra cómo se usan los anestésicos inhalados (sevoflurano y desflurano) dentro de la práctica habitual de los anestesiólogos en las salas de cirugía de un hospital de alta complejidad, así como sus repercusiones ambientales y las consecuencias que estos producen. La relevancia de esta información radica en la huella de carbono de los anestésicos inhalados, especialmente por sus emisiones de gases de efecto invernadero, una preocupación en aumento. **Objetivos:** Evaluar la frecuencia de uso del sevoflurano y del desflurano en la práctica anestésica y analizar la percepción de los anestesiólogos sobre su impacto ambiental y costo. **Metodología:** Estudio descriptivo retrospectivo basado en una encuesta electrónica aplicada en REDCap. La participación fue voluntaria y contó con 40 anestesiólogos, quienes proporcionaron información sobre sus prácticas de administración y disposición de los anestésicos inhalados. **Resultados:** El sevoflurano se utiliza aproximadamente 10 veces más que el desflurano, debido a su menor impacto ambiental y menor costo para el sistema de salud. Además, se evidenció una creciente conciencia entre los anestesiólogos sobre la sostenibilidad ambiental y la necesidad de estrategias para reducir las emisiones de gases de efecto invernadero. **Conclusiones:**El estudio refleja una preferencia clara por el sevoflurano, impulsada por su menor huella de carbono y menor costo. Es fundamental promover estrategias que optimicen el uso de anestésicos inhalados y reduzcan su impacto ambiental en hospitales de alta complejidad.

Palabras clave
sevoflurano; desflurano; huella de carbono; efecto invernadero; medio ambiente humano.

Introduction

Climate change represents a major problem that affects not only humans but also various species, as it alters the global atmospheric composition and the natural variability of the climate (1). It is considered a threat to human health and the survival of some species (2). One of the most significant contributors to climate change is the emission of greenhouse gases generated by various sectors, including the healthcare sector, which is responsible for approximately 4.6% of global emissions (2,3). The carbon footprint in this sector largely depends on services derived from hospital care (4,5), and operating rooms play a significant role due to the use of inhaled anesthetics (6,7).

Modern volatile anesthetics are halogenated substances that are poorly metabolized in the body. As a result, when exhaled, they are released into the atmosphere as residual medical gases, which have a greater global warming potential than carbon dioxide (8,9). The current literature clearly supports the notion that inhaled anesthetics (such as desflurane and sevoflurane) significantly impact the atmosphere by functioning as greenhouse gases (10,11,12). Specifically, it has been documented that the negative effect of desflurane is proportionally greater when compared to other inhaled anesthetics once released into the atmosphere.

During an average workday, each anesthesiologist administering desflurane can contribute the equivalent carbon dioxide emissions of more than one thousand kilometers of driving (4). For this reason, it is of great importance to implement both individual and collective measures that mitigate the environmental consequences of inhaled anesthetics. While there is substantial evidence supporting the environmental impact of inhaled anesthetics, very little has been written about them in Latin America. As a result, we have a limited understanding of how inhaled anesthetics are used locally and their environmental impact in a continent known for its biodiversity. Currently, the Hospital Universitario San Ignacio (HUSI), a high-complexity hospital in Bogotá, Colombia, only has desflurane and sevoflurane as the available inhaled anesthetics in its operating rooms. It is important to note that all operating rooms at HUSI are equipped with a laminar flow system or a halogenated escape control system.

The objectives of this article are 1) to understand how inhaled anesthetics are used in routine practice in the operating rooms of HUSI and 2) to analyze the environmental impact and identify strategies to minimize this impact by

adopting policies that promote sustainability and environmental responsibility.

Methods

A retrospective descriptive study was conducted. Data were obtained from the electronic survey (created in REDCap) titled "Use of Inhaled Anesthetics in the Operating Rooms of HUSI." During the first months of 2024, all anesthesiologists at HUSI were invited to voluntarily complete the survey based on their usual clinical practice. Responses were received from 40 anesthesiologists (i.e., 100% of the anesthesiologists associated with the hospital). Initially, the survey was implemented, and subsequently, the research protocol was developed based on its results, which is why this is a retrospective study. No exclusion criteria were established. The data extracted from the survey were reviewed and used to describe the variables to be evaluated through absolute and relative frequencies.

The survey included several questions, mainly related to the use of desflurane and sevoflurane within the anesthesiologists' usual practice, as well as some questions concerning their knowledge of the environmental impact of these agents. Additionally, through the hospital's central pharmacy, the average monthly consumption in milliliters of both desflurane and sevoflurane at HUSI was determined. This allowed for a more objective and quantitative evaluation of the consumption of these anesthetics.

Experience of a High-Complexity University Hospital

HUSI has 17 clinical specialties and 21 surgical specialties. It serves as a setting for a wide variety of both high and low-complexity surgical procedures, performed on adult patients, as well as pediatric, including neonatal populations. The hospital is equipped with 13 operating rooms, in which procedures are performed on both outpatient and hospitalized patients. Currently, more than 18,000 surgical procedures are conducted annually, which corresponds to approximately 1,500 procedures per month.

Results

The survey "Use of Inhaled Anesthetics in the Operating Rooms of HUSI" was completed by 40 anesthesiologists (55% women and 45% men). The majority of participants were between the ages of 30 and 39 (52.5%), followed by those between the ages of 40 and 49 (20%), as shown in Figure 1.

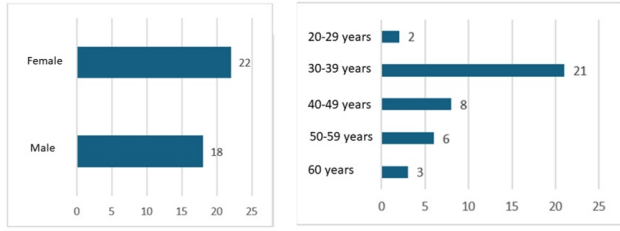

Figure 1.
Characteristics of anesthesiologists who responded to the survey: a) sex and b) age.

Fresh Gas Flow

Regarding fresh gas flow, all anesthesiologists at HUSI use ≤1 l/min. None employ higher flows in their routine clinical practice in the operating rooms, as shown in Figure 2. Additionally, 92.5% of them believe that using low fresh gas flows reduces the environmental impact of inhaled anesthetics, and 100% agree that using low fresh gas flows reduces costs for the healthcare system.

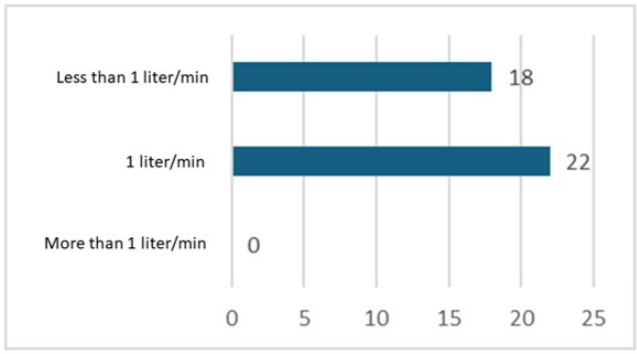

Figure 2.
Fresh gas Flow.

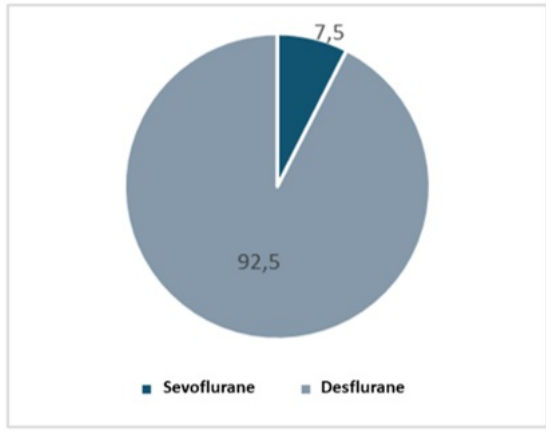

Figure 3.
Environmental impact of inhaled anesthetics: sevoflurane vs. desflurane.

Inhaled Anesthetics

100% of the anesthesiologists at HUSI use sevoflurane more frequently than desflurane in their routine clinical practice. The primary reason for this preference is its lower environmental impact (pollution) and lower costs to the healthcare system. However, there are some specific reasons why anesthesiologists would prefer the use of desflurane over sevoflurane, namely: faster elimination, which is reflected in a shorter awakening time, and the absence of toxic metabolites, as well as its use in obese patients and bariatric surgery procedures.

Environmental Impact

92.5% of anesthesiologists believe that desflurane has a greater environmental impact in terms of pollution (Figure 3). Additionally, 85% of anesthesiologists consider that desflurane generates higher costs to the healthcare system compared to sevoflurane (Figure 4).

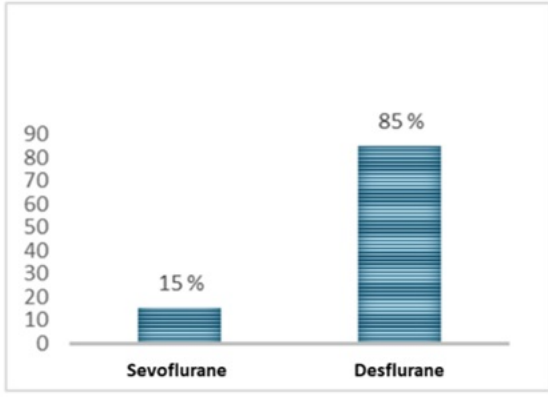

Figure 4.
Health system costs of sevoflurane vs. desflurane.

Consumption of Inhaled Anesthetics in the Hospital

Through the central pharmacy of HUSI, it was established that 7 bottles of desflurane and 73 bottles of sevoflurane are dispensed. Each bottle of sevoflurane contains 250 milliliters, and each bottle of desflurane contains 240 milliliters. Thus, each month, HUSI consumes 18,250 milliliters of sevoflurane and 1,640 milliliters of desflurane. As a result, the consumption of

sevoflurane is significantly higher than that of desflurane, almost 10 times more (Figure 5).

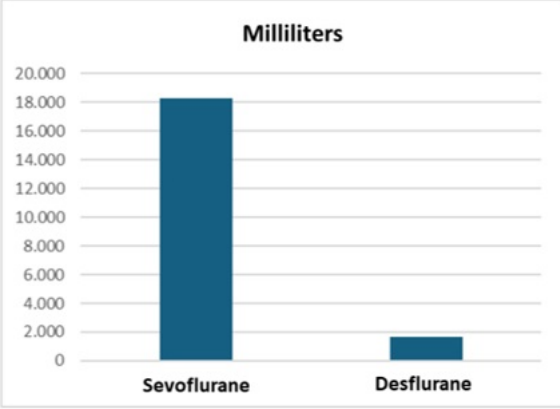

Figure 5.
Consumption in milliliters of inhaled anesthetics.

Discussion

HUSI is a high-complexity hospital in Bogotá, and in the operating rooms, anesthesiologists only have access to desflurane and sevoflurane as inhaled agents. This study revealed that sevoflurane is used far more frequently in routine clinical practice by anesthesiologists, primarily due to its lower environmental impact (pollution), lower costs to the healthcare system, and specific situations such as inhalation inductions in pediatric populations. However, despite the less frequent use of desflurane, it is preferred under certain specific conditions, such as in obese patients, bariatric surgery, and outpatient procedures, where a rapid recovery is desirable to facilitate a fast-track approach in the operating rooms.

When analyzing the environmental awareness or knowledge of anesthesiologists about the potential environmental impact of using inhaled anesthetics, it was found that most are aware of the environmental effects of these agents. The survey indicated that the majority of anesthesiologists consider desflurane to have a greater environmental impact and generate higher costs to the healthcare system. This is one of the reasons why they prefer sevoflurane. This is reflected when analyzing the consumption of each anesthetic agent in milliliters.

According to the data from the central pharmacy, sevoflurane consumption at HUSI is 10 times higher than that of desflurane. In routine practice, the lower use of desflurane has direct implications for greenhouse gas emissions, as well as for costs to the healthcare system. Some studies have demonstrated that the environmental impact of desflurane is approximately 20 times greater compared to sevoflurane (4). This is due to its physicochemical characteristics, which contribute more to global warming through the release of gases like carbon dioxide and trifluoroacetic acid during its metabolism in the body and its degradation in the atmosphere (4).

Concerns about climate change are becoming increasingly important, and there are already strategies in place to reduce greenhouse gas emissions across various sectors. For example, the healthcare sector significantly contributes to these emissions, and inhaled anesthetics undoubtedly have an environmental impact, with the use of desflurane being the most concerning. While our study highlights how inhaled anesthetics are used in our hospital and their potential environmental impact, other studies have shown efforts to educate anesthesiologists on this topic and evaluate changes in awareness and practice patterns, specifically reducing the use of desflurane (12).

From a practical perspective, careful management of both sevoflurane and desflurane is crucial at HUSI. Strategies such as optimizing administration techniques, using low fresh gas flows, carefully selecting the anesthetic agent based on patient needs, and implementing rational use policies can significantly contribute to reducing the environmental footprint.

This study should be considered in light of its limitations, due to its retrospective design and reliance on the memory and perception of the surveyed anesthesiologists. For example, the retrospective nature may introduce recall bias, as respondents may not accurately remember the specific details of their

daily inhaled anesthetic practices. Furthermore, the retrospective survey may not fully capture the underlying reasons behind anesthesiologists' decisions to use inhaled anesthetics, such as individual preferences, availability of agents, or specific institutional policies, which could influence anesthesia choices.

Despite these limitations, this study provides an initial insight into the practices surrounding the use of inhaled anesthetics in a high-complexity hospital setting, which will guide future, more rigorous, prospective research to further assess the environmental impact.

Additionally, it is essential to consider the future availability of more sustainable alternatives, and research should continue into the development of inhaled anesthetics with a lower environmental impact. This includes innovations in anesthetic formulations and the improvement of environmental management practices in hospitals to mitigate adverse effects on the environment while ensuring the quality and safety of medical care.

Conclusions

Sevoflurane and desflurane are fundamental in modern anesthesiology practice. Evidence widely supports their environmental impact, especially desflurane, which has a higher contamination potential. Therefore, the use of inhaled anesthetics should be carefully managed in high-level hospitals to minimize their environmental impact and promote more sustainable clinical practices, such as monitoring the residual concentrations of these gases in exhaled air and implementing efficient administration practices.

In the routine practice of anesthesiologists at HUSI, sevoflurane is used more than desflurane. This preference is based on the knowledge of its lower environmental impact, favorable pharmacokinetic profile, and its ability to provide stable anesthesia with rapid recovery in a variety of complex surgical procedures. However, it is important to note that both inhaled anesthetics impact the environment due to their greenhouse gas emissions, which contribute to global warming and ozone layer depletion.

Despite the preference for sevoflurane in this specific hospital setting, healthcare professionals must be aware of the environmental effects of their therapeutic choices. In this regard, it is essential to promote research and development of more sustainable alternatives in anesthesia, as well as to implement policies that encourage the rational use of resources in daily clinical practice. These efforts can not only benefit the environment by reducing emissions associated with sevoflurane and desflurane but can also lead to improvements in operational efficiency and the long-term sustainability of the healthcare system.

Finally, it is recommended that more exhaustive prospective studies be conducted to evaluate and compare in detail the environmental impact of sevoflurane and desflurane in specific clinical contexts, which could guide hospital policies aimed at more environmentally responsible anesthetic practice.

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Notes

Funding This work was made possible thanks to the Hospital Universitario San Ignacio (HUSI) and Pontificia Universidad Javeriana, Bogotá campus.

Conflicts of Interest The authors declare no conflicts of interest.