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EDITORIAL

Greening the operating room

"Nature does nothing in vain" Aristotle in *On the Soul*

Since Swedish scientist Svante Arrhenius first estimated the extent of warming from widespread coal burning in 1896, climatologist Wallace Broecker coined the term "global warming" in the late 1970s, and the Meadows Report was published in 1972, several meetings have been held on the links between the ecological consequences of economic growth, resource limitation, and demographic trends.[1]

The French Economic Transformation Plan, launched in March 2020, aims to offer pragmatic solutions to decarbonize the economy in each sector. Regarding healthcare, in-depth work will be launched to educate the healthcare sector on its greenhouse gas emissions and the pathway to decarbonization.[2] Indeed, the healthcare sector provides 2.6 million jobs or more than 9% of the active population with emission levels between 40 and 61 $MtCO_2e$ (Metric tons of Carbon Dioxide equivalent), i.e., between 6.6% and 10% of France's carbon footprint.[1,2]

At the global level, according to the nongovernmental organization Health Care Without Harm, the climate footprint of the health sector represents 4.4% of net global emissions, or the equivalent of 2 gigatons of Carbon Dioxide (CO_2).[1] This climate footprint of the global health sector is equivalent to the annual greenhouse gas emissions of 514 coal-fired power plants.[1]

It is therefore imperative that this sector do its part to reduce emissions by 5% per year by 2050 to stay below 2°C.[1,2]

The operating room alone accounts for 40% of these emissions. The three main components of this carbon footprint are: waste production, energy demand, and anesthetic gas emissions.[3–5]

Greenhouse gases, which include water vapor, carbon dioxide, nitrous oxide, halogenated fluorocarbons, and hydrofluorocarbons (HFCs), absorb infrared radiation in the atmosphere, warming the Earth.[5–9] Halogenated chlorofluorocarbons (halothane, enflurane, isoflurane) or fluorinated hydrocarbons (sevoflurane and desflurane) are therefore potentially harmful to the Earth's ozone layer.[5–9] The physicochemical properties of these gases give them the ability to warm the climate because they meet the three characteristics of greenhouse gases: significant infrared absorption throughout their lifetime, long atmospheric lifetime, and the amount or concentration present in the atmosphere.[5–9]

Global Warming Potential (GWP) was developed to allow comparison of the effects of different gases on global warming.[1,2] It is a measure of how much energy emissions from one ton of a gas absorb over a period of time, compared to emissions from one ton of Carbon Dioxide (CO_2).[1,2,5-9] The higher the GWP value, the more a particular gas warms the earth compared to CO_2 over that time period.[1,2] The time period commonly used for GWPs is 100 years.[1,2] The power with which halogenated fluorocarbons contribute to global warming is equal to 1. For example, a single anesthesiologist administering N_2O or desflurane can cause the CO_2 equivalent of more than 1000 km of driving in an average workday.[6]

Developing new methods to reduce resource use, CO_2 emissions, and waste (including toxic byproducts), ranging from minimizing hospitalizations (improving primary care and expanding outpatient procedures) to reducing the use of medications and devices, could help promote a healthy and sustainable future.[5–9]

In 2022, the French Society of Anesthesia and Intensive Care Medicine, in collaboration with the French Society of Hospital Hygiene and the French Society of Clinical Pharmacy, proposed a reference system to reduce the environmental impact of general anesthesia in the operating room.[7]

This work has formulated recommendations to reduce the environmental impact of general anesthesia in the operating room, which we summarize below:[7]

- Considering the same clinical benefit to the patient, anesthesiologists should prefer sevoflurane to desflurane or isoflurane and not use nitrous oxide. They should also limit fresh gas flow during inhalation anesthesia to a maximum of 1 $L.min^{-1}$ and consider the frequency that anesthetic circuits require washing to reduce the environmental impact of general anesthesia.[6,5,8,9]

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- Experts suggest that anesthesiologists use monitoring of anesthetic depth in combination with the fraction of anesthetic vapor exhaled during inhalation anesthesia to reduce anesthetic vapor consumption and thus environmental impact.[10]
- From the point of view of environmental impact, inhaled general anesthesia or total intravenous general anesthesia with propofol could be used indiscriminately; the former has environmental impact due to emission of greenhouse gases, but the latter has ecotoxicity to soil and water.[11,12] Metabolites of intravenous general anesthesia may enter the hospital wastewater system. It is possible that degradation products such as phenol are formed from propofol, but it is not known whether there is significant accumulation in the food chain.[11,12]
- Experts recommend that anesthesiologists give preference to reusable medical devices over disposable ones and choose models that do not contain Di(2-Ethylhexyl) Phthalate (DEHP). Consider other reusable items such as laryngoscope blades, laryngeal masks, scissors, etc. For the same patient, consider the minimum number of syringes required.[6] When using reusable medical devices, inventory procedures should be established to ensure that devices are reused as much as possible to reduce the environmental impact and financial costs.[13–15]
- Concerning healthcare waste in the operating room some actions are proposed:[6,7]
  - Identify your waste and ask the question: can I avoid it, reuse it or recycle it? If not, can I rethink my practices or purchases?
  - Collaborate with the department responsible for waste management and the hospital hygiene team.
  - Integrate selective sorting into the waste management process and in the evaluation of professional practice.
  - Optimize the ergonomics of sorting: choice of bins and their position.
  - Inform and create awareness among staff to sorting at source.
  - Evaluate the financial benefits of sorting at source and recycling sorted waste so that the administration can fund future sustainable development projects (virtuous cycle).
- Last but not least, the health sector cannot be considered in isolation and depends on other sectors, such as:[2]
  - The energy sector, which supplies electricity, oil, and gas to all machines, whether inside facilities (heating, appliances, robotic mixers, and kitchen stoves, etc.) or outside, such as cars and trucks that provide transportation for patients, employees or even supplies.
  - The area of daily mobility, which allows the movement of patients and professionals in this area, and which affects the general health of the population through daily physical activity and air pollution.
  - The agricultural sector, which both provides communal catering in health facilities and influences the general health of the population through daily nutrition.
  - The construction industry to build, maintain and renovate health care facilities, medico-social facilities, nursing homes and medical practices.
  - The area of urban planning that determines the relationship of health facilities to their territory and population.
  - The digital sector, which supports all digital transformations in the health sector, both in the medical field (technological medical devices, patient monitoring, telemedicine) and in administration.
  - The industrial sector to produce the various drugs and medical devices consumed by users in the health sector.[2] For example, the Halogenated Drug Recovery unit was developed by Class 1 Inc. of Cambridge, Ont. It collects anesthetic gases after they leave hospital surgical rooms, strips out the gas molecules and stores them.

Hence, it is imperative for the healthcare sector to actively contribute to preserving a healthy environment and combatting global warming.[1,2] The instances elucidated by expert associations underscore the importance of healthcare professionals embracing this responsibility.

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Conflicts of interest

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References

1. Health Care Without Harm (HCWH). Health care's climate footprint — How the health sector contributes to the global climate crisis and opportunities for action. 2019 Available from: chrome-chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf.
2. The Shift Project. Décarboner la santé pour soigner durablement: Edition 2023 du rapport du Shift Project. Available from: https://theshiftproject.org/article/decarboner-sante-rapport-2023/.
3. Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The Carbon Footprint of Surgical Operations: A Systematic Review. Ann Surg. 2020;272:986—95.
4. Varughese S, Ahmed R. Environmental and Occupational Considerations of Anesthesia: A Narrative Review and Update. Anesth Analg. 2021;133:826—35.
5. Wyssusek KH, Keys MT, van Zundert AAJ. Operating room greening initiatives – the old, the new, and the way forward: A narrative review. Waste Manag Res. 2019;37:3—19.
6. McGain F, Story D, Kayak E, Kashima Y, McAlister S. Workplace sustainability: the "cradle to grave" view of what we do. Anesth Analg. 2012;114:1134—9.
7. French Society of Anesthesia & Intensive Care Medicine. French Society for Hospital Hygiene, French Society of Clinical Pharmacy.

Réduction de l'impact environnemental de l'anesthésie générale. 2022. Available from https://sfar.org/reduction-de-limpact-environnemental-de-lanesthesie-generale/.
8. Feldman JM. Managing fresh gas flow to reduce environmental contamination. Anesth Analg. 2012;114:1093–101.
9. Sulbaek Andersen MP, Nielsen OJ, Karpichev B, Wallington TJ, Sander SP. Atmospheric chemistry of isoflurane, desflurane, and sevoflurane: kinetics and mechanisms of reactions with chlorine atoms and OH radicals and global warming potentials. J Phys Chem A. 2012;116:5806–20.
10. Poon YY, Chang HC, Chiang MH, et al. A real-world evidence" in reduction of volatile anesthetics by BIS-guided anesthesia. Sci Rep. 2020;10:11245.
11. Hu X, Pierce JT, Taylor T, Morrissey K. The carbon footprint of general anaesthetics: A case study in the UK. Resources, Conservation and Recycling. 2021;167:105411.
12. Vollmer MK, Rhee TS, Rigby M, et al. Modern inhalation anesthetics: Potent greenhouse gases in the global atmosphere. Geophysical Research Letters. 2015;42:1606–11.
13. McGain F, McAlister S, McGavin A, Story D. The financial and environmental costs of reusable and single-use plastic anaesthetic drug trays. Anaesth Intensive Care. 2010;38: 538–44.
14. McGain F, Story D, Lim T, McAlister S. Financial and environmental costs of reusable and single-use anaesthetic equipment. Br J Anaesth. 2017;118:862–9.
15. Sherman JD, Raibley LA, Eckelman MJ. Life Cycle Assessment and Costing Methods for Device Procurement: Comparing Reusable and Single-Use Disposable Laryngoscopes. Anesth Analg. 2018;127:434–43.

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