Sustainability in Anaesthesiology: A Swiss Perspective

A Guideline for Sustainable Anaesthesia endorsed by the Swiss Society of Anaesthesiology and Perioperative Medicine

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INTRODUCTION

To fight climate change, the Paris Agreement was negotiated during the United Nations Climate Change Conference 2015. Switzerland has ratified the Paris Agreement in 2017. Its goal is to limit global warming to well below 2 degrees Celsius and pursuing efforts to limit it to 1.5 degrees Celsius, compared to pre-industrial levels. To meet the Paris Agreement, global greenhouse gas emissions must be reduced by half within a decade. [1]
The health care sector in western countries contributes an average of 5-10% of the national greenhouse gas emissions. [2]

The financial, human, and natural resources required by the health care system in its current form are not available to an unlimited extent: the demand for health is unlimited, but resources are finite. A paradigm shift from length of life to quality of life is mandatory. [3] The growing consent and awareness for this necessity led to the publication of positional papers by the Swiss Academy of Medical Sciences SAMS on sustainable development and environmentally friendly health care [3] and the Swiss Medical Association FMH on planetary health. [4]

Various studies have indicated that the entire life cycle of the healthcare supply chain, which encompasses resource extraction, manufacturing, packaging, distribution, use/reuse, and disposal, is responsible for approximately 70% of the total emissions generated by the healthcare sector. [5]

Anaesthesia is an essential component of healthcare delivery; however, it also has a noteworthy and quantifiable impact on the environment. The development, production, and utilization of any anaesthetic equipment, medication (volatile and intravenous), as well as their packaging, contributes to the carbon footprint.
Promoting the delivery of sustainable anaesthesia should focus particularly on changing provider behaviour, as this is the main determinant of healthcare resource use. [6]

Various position papers by national associations on sustainability in anaesthesia have been published lately. [7–12] Most recently, the ESAIC Sustainability Committee presented a consensus document on perioperative sustainability. [13] Furthermore, the ESAIC created the Glasgow Declaration on sustainability in anaesthesia and intensive care in June 2023, reinforced in 2024 by a strategic 3- year roadmap setting standards for sustainability in anaesthesia.

These publications present a shared European perspective of what is feasible and achievable - particularly considering the forthcoming EUF-gas regulations that includes a ban on desflurane by 2026.

FUNDAMENTAL PRINCIPLES

There is global overall agreement on some fundamental principles of this change towards environmentally sustainable anaesthesia. [13,14]

Anaesthesia providers should:

- Minimize the environmental impact of their clinical practice.
- Use environmentally preferable medications and equipment when clinically safe to do so.
- Minimise the overuse/ waste of medications and equipment, energy, and water.
- aim for a healthy work environment (professional wellbeing)
- Incorporate environmental sustainability principles within formal anaesthesia education.
- Embed sustainability principles within anaesthesia research and quality improvement programs.
- Lead environmental sustainability activity within their healthcare organizations.
- Collaborate with industry to improve environmental sustainability.

These changes are achievable with reasonable material resource and financial investment.
Patient safety shall not be compromised by sustainable anaesthetic practices. Current evidence however shows that major mitigation potential is unconnected to health outcome or would even improve public health.
To attenuate the consequences of climate change, every anaesthetist should therefore strive to decrease the carbon footprint of his or her daily activities, continuously assessing potential harm, and benefits for both individual patients and global health. [14] To reach this aim we would like to offer more detailed information and recommendations for action for the daily practice in Switzerland.

ANAESTHETIC AGENTS

The most used anaesthetic agents in Switzerland are either inhaled vapours (Sevoflurane, Desflurane, and Isoflurane) or the intravenous agent Propofol. Whilst inhalational anaesthetics are known to have an environmental impact through greenhouse gas emissions, propofol is ecotoxic to water and soils. [15]

With equal benefit for the patients, it is - according to current knowledge- difficult to make a strong recommendation for one or the other agent from a sustainability point of view. [12,16–18].
Given that the use of desflurane as an inhalation anaesthetic shall be prohibited within the-European Union from 1 January 2026, its use in Switzerland should also be strictly limited.
Previous studies have shown that, for environmental reasons, propofol is superior to halogenated vapours. [19] However, when considering the assessment of the entire life cycle of the active pharmacological ingredients, the respective carbon footprint of sevoflurane and propofol could be equivalent under certain conditions (oxygen/ air mix as carrier gas, minimal flow (0.5 l/min), recapturing device that recaptures and recycles 70% of the halogenated vapours in place). [20]

Regardless of the substance used, it should be a priority to administer general anaesthesia using the smallest necessary quantity of anaesthetics.

When using **anaesthetic gases**, the following aspects should be considered:

- The fresh gas flow (FGF) when using halogenated gases should be as low as possible during induction and steady state of anaesthesia. During steady state it appears to be safe[*] to set FGF for Sevoflurane at low- to -minimal-flow (<1 l/min to < 0.5l/min) whenever safety and technique allow. [8,21–23]

- Desflurane, should only be used when strictly required and no other anaesthetic can be used on medical grounds. [24–26]
- Nitrous oxide should be completely avoided unless there are no alternatives. If N_2O is still used, central N_2O tubing systems should be eliminated and replaced by bottled N_2O as tube leakage accounts for most Nitrous oxide release to the atmosphere. [27–29]
- If anaesthetic gases are used, vapour capture technology (VCT) should be considered. There is still a lack of independent data regarding VCTs own carbon footprint as well their efficiency in a clinical context, but there seems to be potential for a positive impact. [12,20,30]
- Whilst the high-efficiency HEPA filter should be changed between each patient, it is safe to change the ventilatory circuit once per week unless there are visible signs of soiling. [31]
- All infrastructure for anaesthetic gas application should regularly be checked and maintained to avoid leakage.

Ecological aspects of anaesthetic gases

⇨ Halogenated gases are potent greenhouse gases and as such contribute to anthropogenic warming.
⇨ 99% of anaesthetic gases are integrally released into the atmosphere, representing 5% of the carbon footprint in the hospital sector and the largest CO_2 footprint in the operating theatre. [26,32]

Regarding **Propofol** use, the following aspects should be considered:

- According to current evidence, total intravenous anaesthesia and regional anaesthetic techniques seem to have a significantly lower carbon footprint than anaesthetic gases. [21] Propofol emissions mainly steem from its way of application (energy for infusion pumps and infusion sets, production/packaging, propofol wastage)
- However, Propofol is a polluter of water and soils; the respective data are still incomplete. [15]
- A strategy to dispose Propofol and to reduce Propofol wastage should be mandatory: 14-49% of Propofol is being discarded unused. [33,34]
- During total intravenous general anaesthesia, depth of anaesthesia should be monitored to reduce consumption of anaesthetic drugs, environmental impact and financial costs. [12,15]

Ecological aspects of propofol

⇨ Of all the Propofol administered to the patient, 1% is excreted unchanged in the urine. 99% is metabolized.
⇨ non- metabolized Propofol (excreted from patients or from wastage) is highly toxic for aquatic organisms.
⇨ non-metabolized Propofol accumulates in fatty substances and presents a high potential for bioaccumulation and mobility in soil.
⇨ to be completely destroyed, Propofol must be incinerated at 1000°C for at least two seconds. [35]
⇨ Propofol has a PBT Index of 6 out of 9. [36]

EMERGENCY DRUGS

Looking at intravenous agents from a sustainability point of view the focus should be on the procurement chain associated with

[*] Swissmedic currently still recommends an FGF > 1l/min for Sevoflurane. This value is currently under revision.

these agents and their application and on their ecotoxic effects for water and soils.

PBT Index

- ⇨ The PBT Index is a nine-point environmental assessment tool that evaluates the Persistence, Bioaccumulation, and Toxicity of a substance. It is used to determine the environmental hazard of chemicals, including pharmaceuticals.
- ⇨ A comprehensive pharmaceutical environmental risk classification database, utilizing the PBT Index, is accessible through the Health and Medical Care Administration of the Stockholm Region in Sweden. [36]

An average of 50% of emergency drugs prepared in syringes are discarded unused. More sustainable options are to have these drugs prepared under clean conditions by the hospital pharmacy or to purchase pre-filled syringes by pharmaceutical industry which increases the products life span. [37] These alternatives not only reduce the waste of drugs, syringes, needles, and glass ampoules but also the overall cost and furthermore contribute to patient safety by excluding the possibility of drawing up the wrong drug or wrong concentration. [8]

Recommendations:

- Limit the prophylactic preparation of drugs to be used “in an emergency”, use prefilled syringes where possible.
- Anticipate the drug amount needed and open an appropriate smaller vial size.
- Establish procedures for the disposal of IV drugs to minimize any potential for negative environmental effects (spilled on a paper towel and discarded with the hospital waste for proper incineration).
- Minimize discarding drugs through optimized stocking processes.

MEDICAL DEVICES AND WORKPLACE ENVIRONMENT

Hospital care generates a large amount of waste; most of it, approximately 75-90%, has a potential to be recycled. Between 20-33% of a hospitals’ waste are produced in the operating rooms of which up to 25% arises from anaesthesia care alone. [38] Most of this waste stems from medical device and drug usage. To reduce this waste generated, the implementation of 5R (Reject, Reduce, Reuse, Recycle, Repair) policies is paramount.

A. Medical device and equipment usage

To decrease the amount of waste generated, sustainability aspects should become key criteria already in the acquisition process:

- Request life-cycle-assessment information from providers.
- Consider reusable equipment instead of single-use disposables not offering a clear benefit to patients. This is almost always associated with a lower environmental impact and lower costs. [39–43]
- Request energy efficiency labels for new electronic devices.
- Ask for PP or silicone reusable devices over PVC/ DEHP (box).
- Circular economies should be promoted (i.e., keeping materials in use and making efficient use of natural resources). [2,14]

LCA Assessment

- ⇨ The “Life Cycle Assessment” from the U.S. General Services Administration is the toll most frequently used to quantify the environmental impact of a product throughout its entire life cycle, including the raw materials, manufacturing, packaging, distribution, usage and waste processing. [44]
- ⇨ Also known as a "cradle-to-grave" approach.

B. Waste and Recycling recommendations

- Actively monitoring the amount of unused materials significantly diminishes the amount of waste generated by "overage" and associated costs. Appropriate waste segregation is mandatory for increasing the proportion of recycled waste.
- Think twice before opening a sterile package.
- Adapt prepacked kits (for central line insertion, catheters etc.) to local protocols and needs.
- Clarify with your local waste incineration facility which materials can be exempt from general waste.
- Separate and recycle paper/ cardboard, medical plastic (particularly non- woven polypropylene used for wrapping paper has a very high recycling potential) and metal.

Widely used polymers in healthcare

- ⇨ Polypropylene (PP): highly thermal resistant and withstands much higher temperatures than PVC.
- ⇨ Polyvinylchloride (PVC): as higher energy consumption and CO_{2eq} emission than PP. Many single-use devices in anaesthesia are made from PVC (laryngeal masks, face masks).
- ⇨ Diethyl-hexyl phthalate (DEHP): a compound added to impart flexibility to PVC-based products such as intravenous bags, tubing systems or endotracheal tubes. Is labelled as a probable carcinogen and possible endocrine disrupter by the Environmental Protection Agency in the United States.

C. Organisational and educational recommendations

Interdisciplinary green teams should be promoted to find novel approaches to our ways of working- in collaboration with industry, government, and the like.

Environmental sustainability principles should be integrated within formal anaesthesia education and training as well as continuing professional development. The 'carbon costs of health care' should be assessed regarding the connection between the health carbon footprint, health care performance and health outcome.

ENERGY, INFRASTRUCTURE AND WATER MANAGEMENT

Healthcare facilities consume significant quantities of natural resources, with the primary source of these emissions originating from the energy sector. In the operating rooms, heating, ventilation and air-conditioning systems (HVAC) are responsible for 90-99% of the energy consumption. [43] In unoccupied operating rooms HVAC systems can be turned down without impeding infection control an affecting patient safety. Implementing these measures can lead to energy savings of up to 70%. [21,26,45,46]
Hospitals also consume significant amounts of water for various purposes, including routine patient care and specialized areas like dialysis. Consequently, it is crucial to place a greater emphasis on the conservation of water resources in hospitals. By implementing efficient technologies, such as motion sensor-controlled faucets and optimizing sterilization practices, hospitals can minimize water consumption and reduce waste. [21]
Recommendations:

- Implementation of strategies and approaches that target the reduction of significant power consumption related to heating, ventilation, air conditioning in operating theatre suites and intensive care units and other equipment such as computers and lighting systems of workplaces.
- A transition towards renewable energy sources should be considered by the healthcare institutions.
- Consider strategies to address reduction of water consumption such as the use of hand water sensors.

ANAESTHESIA PROVIDER'S WELLBEING AND INDIVIDUAL EMISSIONS

There is rising awareness within the anaesthesiology community that providing sustainable anaesthesia should take into account the importance of wellbeing and the risks related to fatigue- crucial issues in anaesthesia and intensive care, where rapid decision making, technical expertise and high levels of concentration are essential for patient safety. [13]

Furthermore, individual choices regarding anaesthesia provider's emissions from mobility, travelling and nutrition should be taken into consideration

Commutes are highly dependent on fossil fuel-based transportation; by adopting more environmentally friendly transport plans, healthcare systems can reduce their burden on the environment and patients' health.

The carbon footprint of the whole global events industry is causes more than 10% of the global CO_2 emissions.

Switching from in person conference to pure virtual mode reduces the carbon footprint by 94%, while regional hubs for hybrid conferences could slash carbon footprint and energy use by 60–70% while maintaining <50% of virtual participation.[47]

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