Environmental Stewardship in Anesthesia Care

Position Statement, Policy and Practice Considerations

Introduction

Many professional health organizations across the globe recognize the urgent and profound effects of climate change on health as well as their responsibility to address these impacts.[1] There is broad consensus that immediate and sustained action is necessary. The Intergovernmental Panel on Climate Chage (IPCC) details that this must be done by forging a deep and sustained effort at decreasing carbon-based atmospheric emissions by 43 percent and limiting the rise in global temperatures to 1.5 degrees Celsius by 2030, with the goal of carbon neutrality by 2050. If greenhouse gas (GHG) emissions remain unmitigated, global temperatures are expected to rise at an unsustainable rate, intensifying climate instability. The effects of pollution from waste production and processing only add to the complexity of the issue. The resultant effects include loss of species and increase in disease vectors, droughts, hunger, poverty, displacement, and rising seas. The consequences for the health of communities across the planet are known to be social, physical, and mental, and disproportionately affect vulnerable populations as well as countries with lesser resources.

The healthcare industry is among the most carbon-intensive industries in the industrialized world, generating 10 percent of all GHG emissions and having a tremendous impact on toxic air pollution affecting this planet. The healthcare industry is

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the second largest producer of carbon emissions in the United States (U.S.). The operating room (OR) is the largest producer of carbon emissions and one of the largest contributors of waste in the form of disposable single use plastics, enormous energy consumption, and volatile anesthetic gases. Plastics alone contribute to approximately half of all anesthesia waste volume. Additionally, there are many other forms of pollution that healthcare produces in the form of batteries, metals, medications, hazardous waste and otherwise.

These environmental impacts of care are not reflected in the price of care charged to payors and patients. Therefore, the public at large and local and global communities bear the costs of these environmental impacts. As healthcare organizations work to improve the well-being of their communities and society, there is a growing expectation that they also act as stewards of the environment by utilizing sustainable practices of actively minimizing carbon emissions, waste, and pollutants. Corporate responsibility in healthcare extends beyond patient care, as it encompasses the obligation to operate sustainably, recognizing that environmental health is inseparable from public health.

Purpose

The purpose of this resource is to guide Certified Registered Nurse Anesthetists (CRNAs), also known as nurse anesthesiologists or nurse anesthetists, and other healthcare professionals in integrating environmental sustainability into their practice by identifying opportunities and working towards solutions. This resource highlights the importance of understanding and implementing environmentally responsible practices in

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anesthesia care, thereby minimizing the environmental impact of anesthetic agents and associated procedures. While advancing a culture of environmental stewardship, this position statement also underscores the importance of maintaining the highest standards of patient safety and clinical efficacy. It seeks to inspire collective efforts to reduce GHG emissions, decrease waste, and promote sustainable practices throughout anesthesia care delivery, supporting environmental responsibility and patient safety.

Audience

This position statement, along with the accompanying policy and practice considerations, is intended for anesthesia professionals as well as healthcare administrators, policymakers, and environmental sustainability advocates within a healthcare system.

Position

CRNAs play a vital role in ensuring safe and effective anesthesia care and can make positive contributions to environmental sustainability within healthcare by optimizing anesthesia delivery, minimizing waste, and supporting the use of environmentally sustainable anesthetic agents and practices. As leaders and patient safety advocates, CRNAs can directly impact the development and implementation of facility policies and procedures and advise on matters such as OR efficiency, drug formulary decisions, and equipment purchases.

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Addressing the environmental risks posed by anesthesia practice protects the health and safety of patients and providers and promotes long-term sustainability by reducing GHG emissions and ecological harm associated with anesthesia practices.[2,3] By understanding these impacts and implementing environmentally sustainable practices, CRNAs can lead efforts to minimize the environmental footprint of healthcare while maintaining high standards of patient care.[2,3]

Waste Anesthetic Gases

Waste Anesthetic Gas Exposure and Health Complications

Waste anesthetic gas (WAG) refers to anesthetic gases and vapors, such as nitrous oxide (N_2O) and halogenated agents like sevoflurane, isoflurane, and desflurane, that are released into the OR during a medical or surgical procedure. Healthcare workers in this environment are at risk of occupational exposure, which has been associated with both acute effects and chronic health risks, as detailed in Table 1. These potential outcomes underscore the importance of implementing and maintaining stringent safety protocols to minimize occupational WAG exposure.

Table 1. WAG Health Effects

Acute: health effects that typically manifest soon after exposure, impacting immediate well-being.

- Headaches
- Irritability
- Fatigue
- Nausea
- Drowsiness
- Dizziness
- Impairments in judgment, coordination, and cognitive performance

Chronic: health effects that may develop over prolonged or repeated exposure periods, are more severe, and can have lasting implications.

- Neurological, liver, and kidney disease
- Reduced brain efficiency
- Irritation of the respiratory tract
- Cancer
- Reproductive health concerns
  - Miscarriages
  - Infertility in both males and females
  - Increased risk of birth defects

Recognizing and managing workplace exposure to WAGs, particularly from volatile anesthetics and N_2O gas, is essential to protect anesthesia professionals from adverse health effects. For example, chronic occupational exposure to N_2O has been linked to infertility, miscarriages, and neurological, renal, and liver disease when levels exceed recommended limits. While the Occupational Safety and Health Administration (OSHA) does not currently have a federal recommendation for N_2O levels, the National Institute for Occupational Safety and Health (NIOSH) recommends a time-weighted average (TWA) exposure limit of 25 ppm during anesthetic administration to minimize risks.

To protect healthcare workers from the effects of WAGs, employers should:

- Monitor airborne WAG concentrations, including N_2O.
- Implement engineering controls, such as effective scavenging and ventilation systems, safe work practices, and regular equipment maintenance.
- Adopt occupational exposure limits (OELs). Establish and regularly update policies and procedures that protect healthcare workers and promote exposure that does not exceed the OELs.
- Provide ongoing education and training on standard operating procedures, exposure controls, and the use of personal protective equipment (e.g. respirators).

Waste Anesthetic Gas Exposure Risk

Common sources of WAG exposure include leakage from tubing, seals, and gaskets, poor work practices or lack of training, inadequate ventilation, poor ventilation standards, and ineffective gas scavenging systems. Although OSHA does not have specific standards for WAGs, it provides general workplace safety guidance and emphasizes the importance of controlling harmful exposures.

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The anesthesia workstation presents several risks for WAG exposure:

Filling the Vaporizer: Take extreme care while filling the vaporizer. Overfilling of a vaporizer or spilling liquid anesthesia agent while placing the adaptor on the volatile container can increase the concentration in parts per million (ppm) of the volatile gas in the OR and/or even be absorbed into the body. Follow facility standards in disposal of empty volatile containers.

Gas Leaks: Heighten awareness of any sources of gas leaks. Circuit tubing, bags, seals, gaskets, and vaporizers are all potential sources of leaks. Loss of pressure or suboptimal pressure in the anesthesia delivery system should cue the anesthesia professional into the possibility of gas leaks, especially if the flow needs to be maintained at an increased rate during the case. This is also potentially true within the high-pressure system between the N_2O cylinder and the yoke assembly or between the anesthetic gas column outlets and the N_2O hose.

Be careful not to empty the gases while purging or flushing the anesthesia delivery system with the oxygen flush valve. Leaks can occur from where the circuit connects to the patient, such as around the mask without an adequate seal, the endotracheal tube if the cuff is not properly inflated, or with excessive leak during the use of a laryngeal mask airway.

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Scavenging System: Check the WAG scavenging system for optimal functioning. Causes of leaks could include limited air exchange in the OR or an obstructed venting tube in a passive system and an ineffective or inoperable vacuum system. The general environment of the OR could facilitate higher gas waste in the event of ineffective or poor room air exchangers and gas that is exhaled from the patient's airway at the end of the case during emergence, transport, and into the PACU period especially during a deep emergence. Safety should be the main factor in caring for the patient; however, WAG exposure mitigation techniques should be considered.

Strategies for Reducing WAG Exposure in the OR

Follow manufacturers' instructions and safety precautions for the appropriate use of each type of anesthesia delivery system. WAG removal systems are classified as either active (i.e., using applied suction) or passive (i.e., relying on positive pressure and corrugated tubing to direct gases to the room ventilation exhaust grill of the OR). Active systems are generally more effective than passive systems, as they better compensate for unknown leaks within the scavenging system. In active systems, anesthesia professionals should be aware of safety mechanisms that protect the patient from negative suction pressure and from possible positive pressure buildup due to malfunction. Passive systems require protection only from possible positive pressure buildup.

The scavenging system must be properly maintained to collect and remove WAGs. Air exchanges in the OR should be verified to be efficient and not blocked by other equipment. Scheduled preventative maintenance and inspection of the anesthesia workstation and scavenging system should be routine and documented. The scavenging system should be independent of the main facility ventilation system and must not discharge gases near facility air intakes. All gases and vapors should be scavenged outside of the building following local standards. A properly designed and fully operational ventilation system is important to minimize WAG concentrations in all recovery room spaces.

When designing ventilation for OR and non-ORs, refer to regulatory authorities and official resources at the federal, state, and local levels, as well as resources from facility accreditation organizations and other pertinent professional organizations. These organizations include, but are not limited to:

- American Institute of Architects (AIA)
- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (AHSRAE)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Administration (OSHA)
- National Institute for Occupational Safety and Health (NIOSH)

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Mitigating WAG is one element considered when determining the appropriate air exchange levels within the facility. Other elements include, but are not limited to:

- The class of operating and procedure rooms
- Types of procedures to be performed
- Layout of adjacent spaces (e.g., ORs)
- Building ventilation design
- Energy efficiency

Determining the appropriate air exchange rate and air sampling frequency and procedure for facility rooms (e.g., ORs, procedure rooms, PACU) should be a collaborative process led by facility engineers and architects. A properly designed and maintained heating, ventilation, and air conditioning (HVAC) system can also contribute to the dilution and removal of WAG not collected by the scavenging system.

Implement Monitoring, HEPA Filtration, and Ventilation Best Practices

Routine monitoring of WAG levels and regular leak testing of anesthesia delivery systems are imperative for detecting potentially harmful concentrations of N_2O and volatile anesthetics. Anesthesia professionals should adopt best practices such as turning off anesthesia machines during downtimes, pausing automatic ventilation when patients are disconnected from the circuit, and using HEPA filtration and suction to minimize occupational exposure. Monitoring N_2O tanks and connection sites for leaks is crucial, especially as many facilities transition from piped to tank-based N_2O delivery to reduce pipeline-associated leaks. Additionally, reducing the volume of volatile anesthetics can be achieved by employing low fresh gas flows, utilizing efficient CO_2 absorbents, and conducting frequent system leak checks. These strategies collectively help protect both staff and the environment from the adverse effects of anesthetic gases.

Perform Routine Leak Testing and Maintenance of Anesthesia Machines

Preventative maintenance is important to safeguard the proper functionality and operation of anesthesia machines and scavenging systems. Maintenance programs should strictly adhere to manufacturer recommendations, including regular inspection, cleaning, testing, lubrication, and adjustment of both anesthesia and scavenging system components. Damaged or worn parts must be promptly replaced to prevent equipment failure or gas leaks. Scheduled leak testing should be conducted on volatile anesthetic and N_2O supply lines, tanks, and anesthesia machines, and address any sources of WAG exposure. All maintenance activities should be documented, including the date, details of the work performed, and the personnel involved.

Sustainable Anesthesia Practices

Consider Environmental Data When Choosing Volatile Anesthetics

Global Warming Potential (GWP) is a measure used to compare the impact of different GHGs on the Earth's climate. It quantifies how much energy the emission of one ton of a gas will absorb over a specific time period (typically 100 years), relative to the emission of one ton of CO_2, which is assigned a GWP of 1. The GWP compares the contribution of radioactive and atmospheric properties of a particular agent. Understanding the effects of anesthetic gases is essential to recognize how anesthetic selection and fresh gas flow influence anesthesia's contribution to GHG emissions and climate change. Anesthesia professionals should consider the GWP and life cycle of medications and volatile anesthetics when selecting anesthetic agents to minimize the effect on the environment. When making formulary and medication purchase decisions, facilities should collaborate with CRNAs, as leaders, subject matter experts, and patient safety advocates. Efforts should be made to choose more environmentally friendly medications or volatile anesthetics whenever possible, without compromising patient safety or outcomes. Table 2 summarizes the GWP of common anesthetic agents.

Table 2. GWP of Common Anesthetic Agents

Agent	**GWP (20/100 yr)**	**Atmospheric Lifetime**	**Ozone Depletion**	**Environmental Impact Notes**
Desflurane	2,540 / 254	9–21 years	No	Most potent volatile GHG
N_2O	289 / 273	114 years	Yes	Major ozone depleter
Sevoflurane	440 / 130	1–5 years	No	Lower GWP, shorter atmospheric lifetime
Isoflurane	1,400 / 510	3–6 years	No	Moderate GWP

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Reduce Desflurane and N_2O (High GWP)

Anesthesia delivery involves the use of many medications that overall are significant contributors to the GHG effect. Opportunities exist within anesthesia practice for increased environmentally sustainable clinical practice through changes to volatile gas selection and limiting waste. With approximately 200 million anesthetic procedures performed globally each year, reducing the use of high-GWP agents can meaningfully lower the environmental impact of anesthesia practice. Volatile anesthetics, particularly desflurane and N_2O, significantly contribute to CO_2 formation in the atmosphere and climate change due to their high GWP and long atmospheric lifetimes. Desflurane is recognized as the most potent GHG among volatile anesthetics, while N_2O not only drives global warming but also depletes the ozone layer. N_2O and volatile halogenated ethers, including desflurane, isoflurane, and sevoflurane, collectively warm the lower atmosphere by reducing the amount of heat radiated from Earth back into space. Volatile anesthetics undergo little metabolism in the body; therefore, they are frequently exhaled or scavenged in the OR in the unchanged form. Notably, in 2006, N_2O accounted for 3 percent of the total GHG emissions in the U.S. In addition to the impact on the ozone layer and global warming, liquid anesthetic agents may also find their way into the drinking water supply and soil, thus adversely impacting public health.

The use of volatile anesthetic agents contributes logarithmically to a facility's carbon footprint. Globally, many facilities and anesthesia departments have discontinued the use of N_2O, and new hospitals are increasingly forgoing N_2O pipelines. Similarly, desflurane is being removed from formularies or restricted due to its significant environmental impact.

Optimize Fresh Gas Flows (FGFs) to Minimize Excess Gas Waste

When volatile anesthetic agents are used, anesthesia professionals can take several steps to minimize environmental impact. Choosing sevoflurane where possible and avoiding N_2O are important first-line strategies. Additionally, during the anesthesia maintenance phase, anesthesia professionals can optimize the FGF rate to the minimum required, thus significantly reducing excess gas waste. The recommended FGF rate in the maintenance phase is no more than 1 L/min. High FGF rates, especially if inadvertently maintained, are a major source of volatile anesthetic gas pollution. Research confirms that using low FGF rates with sevoflurane is both environmentally and clinically safe.

Due to desflurane's lower potency, as much as three times more gas may be emitted per anesthetic compared to other agents. When combined with an unnecessarily high FGF rate (>2 L/min) during the anesthesia maintenance phase or a prolonged case duration, desflurane waste increases exponentially compared to isoflurane or sevoflurane. While higher FGF rates may be used transiently at the beginning of a case or for overpressure techniques utilized to increase the end tidal alveolar gas measurement, anesthesia professionals should remain vigilant and return to a low FGF rate as soon as possible to limit environmental harm.

Consider the Use of Total Intravenous Anesthesia (TIVA) and Regional Anesthesia

Sustainable anesthesia practices can be facilitated by choosing techniques that avoid inhaled anesthetic agents when appropriate. Using TIVA and/or regional anesthesia, when safe and appropriate, reduces the GWP of the anesthetic delivered and offers several clinical advantages for patients. Notable clinical benefits of TIVA and regional anesthesia include a lower incidence of postoperative nausea and vomiting (PONV), faster recovery times, superior pain control, and improved patient satisfaction. In addition to improved outcomes, use of TIVA and/or regional anesthesia may result in cost savings. For example, reducing PONV can prevent unanticipated admissions or delayed discharge resulting in faster recovery, thus directly improving efficiency and lowering costs.

Volatile anesthetic agents have been shown to have potential cognitive risks, especially in the extremes of age, which have not yet been associated with TIVA. TIVA offers other advantages over inhaled agents. For example, propofol may preserve cell-mediated immunity and inhibit tumor angiogenesis with certain cancers. TIVA is easier to reliably titrate in certain cases, including airway cases.

Pharmaceuticals and volatile anesthetic agents both have environmental impacts through carbon-intensive manufacturing, packaging, shipping, and disposal. The pharmaceutical industry accounts for approximately 25 percent of the healthcare industry's carbon emissions.

The environmental effect comparison between TIVA and inhaled agents is much less clear given the lack of scientific evidence comparing the environmental effects of each modality. While volatiles directly and disproportionately contribute to the GHG effect, pollution, and climate change, the effect of pharmaceuticals is apparent on water quality, aquatic ecosystems, and water consumption while generating significantly more plastic waste. Volatile anesthetic agents, except perhaps N_2O and desflurane, remain important to have on a facility formulary due to their versatility and cost-effectiveness, particularly in resource-limited areas. Clinically, the advantages of TIVA for patient care and improved outcomes are driving its adoption within anesthesiology practice, when appropriate. Both TIVA and regional anesthesia offer similar safety profiles and hemodynamic stability under proper management, making them increasingly preferred anesthetic choices for anesthesia professionals. Notably, regional techniques can be a sole anesthetic but most frequently involve sedation, TIVA, or volatile anesthetic use in combination. In the event of utilizing regional with the need for amnesia, the use of TIVA is increasingly becoming the preferred choice as well.

Waste Management and Disposal

Minimize Single-use Plastics and Waste Generation

Hospitals are the largest contributors to healthcare waste, with surgery being a particularly energy-intensive and waste-producing activity. The OR generates the most waste within the hospital, accounting for 21-33 percent of all solid hospital waste.

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Anesthesia contributes 25 percent of OR waste. Both surgery and anesthesia are a significant focus for waste reduction efforts to eliminate pollution and decrease the carbon footprint. Sources of solid waste generated from hospitals include disposable laryngoscope blades, single-use plastics, regulated medical waste, sharps, and pharmaceutical waste. There are many actions that anesthesia professionals can take to mitigate the environmental impact of each of the solid waste produced.

Plastic waste is present in every ecosystem worldwide in multiple forms (e.g., microplastics) with profound environmental effects. The U.S. Environmental Protection Agency (EPA) reports that in 2018, 35.7 million tons of plastic waste were generated, with only 8.7 percent recycled. Globally, from 1950 to 2015, an estimated 7.8 billion tons of plastic were produced, while 9 percent has been recycled, while 12 percent was incinerated, and 79 percent discarded in landfills. On average, each piece of plastic can take up to 450 years to degrade, and current waste management systems are insufficient to handle the scale of this problem.

To complicate matters further, over the past 30 years, the number of operational landfills has declined, and opportunities to produce new landfills are limited due to construction cost and lack of available land. The COVID-19 pandemic further exacerbated these challenges. The use of single-use plastics (SUP), notably for personal protective equipment (PPE), quadrupled thus overwhelming incinerator capacity and causing landfill overuse. Incineration of plastics releases GHGs and toxic

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emissions, while landfilled plastics pose a serious threat to public health in the form of infection and disease.

The environmental impact of plastic waste can be significantly mitigated when anesthesia professionals critically assess and optimize their use of resources. Given the substantial environmental impact of surgical procedures, it is important to propose a circular economic approach in perioperative care. By embracing the principles of "reduce, reuse, and recycle," anesthesia professionals can minimize resource consumption and waste generation, contributing to a more sustainable healthcare system.

A goal in anesthesia delivery is to reduce the volume of plastics disposed of by avoiding disposable items and favoring reusable alternatives where possible, without compromising patient safety. Successful strategies include the use of multi-use ventilator circuits, and the replacement of disposable laryngoscope handles and pulse oximetry probes with reusable ones. Conscientious avoidance of unnecessary supply use is another effective approach. Anesthesia professionals can significantly reduce waste by opening supplies only when needed, rather than in anticipation of possible use where this can safely be done. Although these interventions are limited in scope, they have the potential to significantly reduce plastic waste. Recycling is another way anesthesia professionals can extend the lifecycle of plastics, further minimizing their environmental impact and ultimately reducing plastic waste.

The use of single-use disposable items in the quest for sterile or hygienic patient-related products is a major contributor to all waste derived from the OR. Solid waste from the OR can be separated into two primary sources: generalized solid waste (85 percent) and biohazardous or regulated medical waste (RMW) (15 percent). The generalized solid waste component is comparable to waste that would be derived from a domestic household in the form of paper, plastic disposables, and packaging materials. RMW would encompass all sharps, pharmaceuticals, and waste not contaminated with human blood or infectious materials. OR solid waste must undergo rigorous treatment prior to disposal, unlike household solid waste that is disposed of in landfills essentially untouched after the disposal process. Plastic packaging is a primary component of medical-related solid waste in the OR. While additives in plastics improve their protective properties, they also make plastics resistant to natural degradation, contributing to long-term environmental pollution and increased costs.

Recycle and Reprocess Anesthesia Equipment

Various strategies have been proposed to decrease the environmental impact of ORs, particularly in terms of GHGs and pollution. Prioritizing the reuse of products that do not increase infection risk is a primary recommendation. When disposable products are necessary, participation in a recycling program is encouraged. Manufacturing from recycled materials can reduce the need for raw materials and associated energy use by 50-66 percent, while also decreasing landfill waste. It is estimated that 40 percent of anesthesia waste is potentially recyclable.

Reprocessing of noncritical equipment that encounters unbroken skin (e.g., pulse oximeters) can make a significant impact on waste reduction. The OR environment has many products whose manufacturing, supply chain, use, and disposal increase both the facility's costs and environmental impact through contributions to GHG emissions and medical waste.

When extrapolated over a one-year period at a single institution performing 60,000 intubations, disposable laryngoscope handles alone generated approximately 25 times more GHG emissions than comparable reuseable options, while also increasing costs by an estimated $495,000. While reusable laryngoscope blades can be reprocessed with high-level disinfection or sterilization to minimize infection risk, improper reprocessing poses a risk of pathogen transmission and infection. Facilities should also consider cost, as the expense of reprocessing reusable blades, including labor, equipment, and compliance monitoring, can sometimes make disposable blades a more economical choice despite their environmental impact. Facilities make business decisions balancing supply costs, corporate environmental responsibility, and best practices for patient safety.

Although manufacturers often label these items as single-use, regulatory bodies do not mandate this designation. Reprocessing allows these products to be diverted from landfills, reduces the need for new manufacturing, and conserves raw materials. This approach not only decreases solid waste but may impact operating margins for healthcare systems.

There are many opportunities to recycle plastics in anesthesia practice. General anesthesia produces 48 percent of plastic waste by weight, with more than half being potentially recyclable, as noted in Table 2.

Table 3. Recyclable Anesthesia Equipment

Polypropylene (PP)
• Plastic bins • Plastic Wrappers • Syringes
Polyvinyl Chloride (PVC)
• Transparent wrappers • IV tubing • Oxygen tubing • IV bags
Other
• Ventilator circuits

These products are high volume anesthesia supplies. With proper waste stream management, these plastics can be diverted from landfills and recycled efficiently. Notably, plastic wrapper waste is considered the easiest high-volume waste to recycle.

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A well-planned recycling program enables proper sorting of up to 80 percent of recyclable plastics, primarily wrappers, before the patient arrives in the OR.

Properly Dispose of Expired, Unused, and Used Anesthetic Drugs

Pharmaceutical waste, including expired, unused, or partially administered drugs, poses significant environmental risks. Improper disposal leads to drug residues entering water systems, with documented contamination of surface water, groundwater, drinking water, and soil globally. Partially administered anesthesia drugs lead to drug waste and increased expense. Propofol, which accounts for up to 45 percent of all anesthesia drug waste, is facing increasing scrutiny because it does not degrade, accumulates in body fat, and is toxic to aquatic life. It is also expensive and requires incineration for terminal disposal. Although up to 50 percent of propofol drawn up is ultimately wasted, there is evidence that only a small fraction ever reaches water systems. Nonetheless, strategies like limiting vial sizes to ≤50 mL can reduce waste.

CRNAs can mitigate pharmaceutical waste by:

- Appropriately disposing of drug waste in designated bins (e.g., blue, black, sharps) so the ecosystem can be spared from hospital drug waste.
- Consider delaying medication preparation until immediately before administration in circumstances that the anesthesia provider deems safe to do so.
- Advocating for prefilled syringes, which reduce both medication errors and waste.

Persistent messaging, healthcare provider education, and facility awareness can substantially increase appropriate disposal and reduce inappropriate medication waste.

Properly Dispose of Sharps

Proper sorting and disposal of sharps is a major environmental concern. Sharps are those objects that can penetrate the skin including loose needles, scalpels, broken glass, and ampules. Sharps are RMW and must be disposed of in designated red bins. However, improper disposal is common and non-sharps items, such as unbroken vials, glass, drug waste, and syringes are frequently placed in sharps bins. The misclassification mixes recyclable general waste with RMW, increasing disposal cost and environmental harm due to unnecessary incineration, which releases toxic gases. Knowledge deficits persist as the primary barrier to proper sharps disposal. Anesthesia professionals can play a proactive role in educating themselves, their colleagues, and teams on appropriate waste and sharps segregation.

Facility Corporate Responsibility and Energy Conservation Strategies

Facilities should work with an interdisciplinary team to do the following:

- **Utilize energy-efficient anesthesia equipment and OR practices**
    - Recognize that the majority of energy consumption in healthcare facilities stems from air changes, temperature control, and humidity management rather than general equipment use.
    - Reduce unnecessary energy use by identifying and adjusting air exchange rates in unoccupied ORs, which do not require 20 air changes per hour.

  - Take proactive steps during low census periods or OR inactivity to lower energy consumption, reduce costs, and minimize the facility's carbon footprint.
  - Understand that air flow, combined with temperature and humidity control, can account for approximately 50 percent of a typical healthcare facility's energy and water use.
  - Implement motion sensor-activated lights to reduce unnecessary energy consumption and assist with temperature regulation in the OR space.
  - Use LED bulbs for surgical field lighting to achieve substantial energy savings and reduce overall operational costs.
- **Reduce OR power consumption when not in use**
  - Turn off the anesthesia machine and scavenging system when they are not in use.
  - Opt for bulk processing of surgical instruments and anesthesia equipment that requires frequent cleaning to lower overall energy consumption and achieve potential cost savings.
- **Utilize smart OR design to maximize energy efficiency**
  - Recognize the importance of limiting environmental impact as part of establishing a "green" OR.
  - Follow LEED (Leadership in Energy and Environmental Design) standards by the U.S. Green Building Council to ensure environmental friendliness.
  - Address six key areas of green design in LEED-certified ORs:

        - Sustainable sites
        - Water efficiency
        - Use of environmentally acceptable materials and resources
        - Indoor air quality standards
        - Innovation in the design process

- **Implement sustainable supply chain practices**
    - Consider life cycle emissions and costs when choosing between single-use and disposable equipment and supplies.
    - Implement reprocessing to contribute to both cost savings and emission control compared to discarding single-use devices after each use.
    - Establish a robust recycling program to further decrease emissions, particularly when the use of single-use items is unavoidable.
    - Recognize that procedure kits can generate significant waste as they are often tailored to individual preferences rather than global use.
    - Regulate procedure kits by including only essential items that multiple practitioners can agree upon to reduce waste and emissions from disposing of unused items.
    - Carefully consider equipment upgrades, prioritizing options like refurbishing, donation, repurposing, or recycling through third-party green vendors.
- **Implement WAG recycling or destruction technology**

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- Due to minimal renal and hepatic metabolism of inhaled agents, most expired volatile anesthetics are emitted into the atmosphere unchanged. Increasing technological advancements offer solutions to mitigate the environmental impact of WAGs.
- Halogenated drug recovery (HDR) systems capture up to 99% of exhaled volatile agents (e.g., desflurane, sevoflurane) through desorption techniques, requiring filter replacement only every six months, greatly reducing a facility's carbon footprint.
- Gas destruction technologies chemically break down halogenated agents, minimizing their release into the atmosphere.
- The facility will need to assess the cost-benefit feasibility of these systems; their potential to reduce a facility's carbon footprint is noteworthy. Awareness of these options is important for facilities aiming to align their corporate responsibility goals.

Create a Culture of Sustainability in the Anesthesia Department

Current initiatives in environmental sustainability within anesthesia are multifaceted and evolving. Institutions are implementing anesthesia report cards that track provider habits, such as FGF rates and anesthetic agent selection, to encourage sustainable choices. Grand rounds and continuing education presentations increasingly highlight the ecological impact of anesthesia and strategies for greener practice. Educational programs are incorporating environmental content into coursework, ensuring that sustainability is embedded in early professional development. Additionally, committees dedicated to sustainability in anesthesia are fostering interdisciplinary collaboration, allowing cross-pollination of ideas between stakeholders including administrators. These efforts aim to create cultural change within the profession, building commitment to sustainability at institutional and individual levels. Research initiatives are also advancing metrics for assessing environmental impact, helping to quantify anesthesia-related emissions and develop more effective strategies for mitigation. Collectively, these initiatives signify a growing dedication to integrating sustainability into the fabric of anesthesia practice, reinforcing the profession's responsibility to balance patient safety with environmental stewardship. Environmental initiatives require teamwork, especially in the OR.

Clinically, all anesthesia professionals should receive proper training and retraining as to the functionality and maintenance of the anesthesia workstation, anesthesia machine, scavenging system, and all related information pertaining to the leaks of anesthetic gases. Staff should be alert and ready to communicate noted needs for maintenance and routine checks of volatile related devices.

Comply With Applicable, Laws, Regulations, and Guidance

Working in partnership with facility leadership to promote a sustainable workplace is essential to decrease the carbon burden from the OR, provide a safe internal environment, and reduce release of harmful components into the atmosphere.

Adhering to institutional policies that are designed according to national policies can support the mission of the organization to foster safety mandates for providers and patients.

Advancing Research in Environmentally Sustainable Anesthesia Practices

Ongoing research of sustainable anesthesia practice continues to identify opportunities for reducing the environmental impact of anesthesia, which is recognized for its high carbon footprint. There are many resources listed in this document that are helpful in extrapolating this research. Numerous studies emphasize the need for further discovery and quality improvement initiatives to implement known sustainable practices. Evidence-based interventions promoting environmental sustainability require a team-based approach, continuous monitoring, constant messaging, and fostering culture change. While essential, these best practices remain understudied.

Nurse anesthesia educational programs can advance these goals by integrating environmental sustainability into education and DNP quality improvement studies. Healthcare institutions can lead through awareness initiatives and interventions, including environmentally conscious sourcing, recycling, and waste reduction. Supporting ongoing research and publishing effective and innovative solutions are encouraged to offer guidance for further action.

Conclusion

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As global healthcare continues to advance, there is a growing recognition of the profound impact of healthcare practices, including anesthesia, on environmental sustainability. CRNAs and other healthcare professionals have a unique opportunity to lead the charge in environmental stewardship, ensuring that patient care is delivered not only safely and effectively but also sustainably. Active participation in extending resource life cycles, reducing emissions and waste production, and fostering culture change within healthcare settings where anesthesia is provided, exemplifies a commitment to environmental responsibility.

This document has outlined a comprehensive approach to integrating sustainability into anesthesia care; emphasizing best practices for equipment use, supply chain management, facility design, and clinical strategies such as low-flow anesthesia, use of environmentally favorable anesthetic agents, and TIVA where appropriate. Moreover, the importance of interdisciplinary collaboration, education, and continuous research has been highlighted to drive culture change and foster innovative solutions for greener healthcare delivery.

Technological advancements continue to improve anesthesia administration while mitigating the environmental impact of WAGs. Anesthesia professionals should remain vigilant and proactive in identifying and adopting new technologies and innovations that promote environmental stewardship while maintaining high standards of patient care. By embracing sustainable practices, advancing education, and championing environmental responsibility, CRNAs and their colleagues can make meaningful contributions toward a healthier planet for future generations.

Other Resources

- The Anesthesia Gas Machine 2025
    - Developed and maintained by Michael P. Dosch, PhD, CRNA and Darin Tharp, MS, CRNA
- Occupational Safety and Health Administration (OSHA)
    - Waste Anesthetic Gases
    - Anesthetic Gases: Guidelines for Workplace Exposures
    - OSHA Technical Manual (OTM) Section VI: Chapter 1 Hospital Investigations: Health Hazards
    - OSHA Hospital eTool focuses on hazards and controls found in the hospital setting, describes standard requirements, and recommends safe work practices.
        - See Surgical Suite for WAG
    - White paper: *Sustainability in the Workplace: A New Approach for Advancing Worker Safety and Health*, highlighting the importance of including worker safety and health in the sustainability movement.
- National Institute for Occupational Safety and Health (NIOSH)
    - Waste Anesthetic Gases–Occupational Hazards in Hospitals, Publication Number 2007-151 (Sept 2007)

  - Control of Nitrous Oxide in Dental Operatories, Publication Number 96-107 (1996)
  - NIOSH Warns: Nitrous Oxide Continues to Threaten Health Care Workers (June 1994)
  - Guidelines for Protecting the Safety and Health of Health Care Workers, Publication Number 88-119 (Sept 1988)
  - Criteria for a Recommended Standard: Occupational Exposure to Waste Anesthetic Gases and Vapors, Publication No. 77-140 (March 1977)
- American Society of Anesthesiologists
  - Greening the Operating Room and Perioperative Arena: Environmental Sustainability for Anesthesia Practice
- American Industrial Hygiene Association and American Society of Perianesthesia Nurses
  - Recognition, Evaluation and Control of Waste Anesthetic Gases in the Post-Anesthesia Care Unit White Paper (October 2021)
- American Dental Association
  - Nitrous Oxide Use in Dental Offices
- American Hospital Association
  - The Health Care Leader's Guide to Sustainability and Environmental Stewardship
- The Climate Health Alliance

- A global network of leaders in the healthcare industry and beyond who have created a broad library of resources pertaining to sustainability.

- The Lancet Planetary Health and The Lancet Countdown
  - An open access journal pertaining to all things regarding the environment and an expert collaboration bringing together environmentally related scientists and healthcare professionals,
- Practice Greenhealth
  - A prominent resource used in the healthcare sector for all things that can support sustainability initiatives and the efforts to reduce carbon footprints.
- United States Environmental Protection Agency Sustainability Plans
  - The EPA regulation of pharmaceutical disposal falls under the Resource Conservation and Recovery Act (RCRA).
  - Air quality in the healthcare setting is regulated by the Clean Air Act (CAA).
- World Health Organization
  - Sustainability Practices at WHO

References

Note: References supporting the content of this document will be made available upon the approval of the document.

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