Title:

The climate crisis – actions to prioritise for anaesthesiologists

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Current research was reviewed using keywords: climate change, anaesthesia/anaesthetics, sustainable healthcare, environmentally friendly anaesthesia, unnecessary anaesthesia, climate change extreme weather events, reusable operating room equipment, health and climate crisis. Most reviewed articles were published in the last 18 months, with exceptional references made to older articles that are still very relevant today. The most recent references were published in 2024 and the oldest in 2017. Google scholar was the primary database searched. Research and review articles were analysed and used, as well as exceptional news articles on websites such as the Green NHS website and guidelines on the Association of Anaethetists website. Content that was relevant to sustainable anaesthesia and that was recent was reviewed and considered.

Introduction

This review article outlines the urgency of the climate crisis and introduces accessible actions anaesthetists, other healthcare stakeholders and players, and every person can do that will help tackle this crisis as well as improve healthcare. In so doing, it seeks to expand upon The World Federation of Societies of Anaesthesiologists' published principles of environmentally sustainable anaesthesia [1].

Anthropogenic Climate Change is Accelerating

Human activity (mainly the burning of fossil fuels and changes in land use) is adding 'greenhouse gases' (GHGs, such as carbon dioxide (CO_2) and methane (CH_4)) to our atmosphere, where they allow the passage of short-wave solar radiation, but trap longwave radiation (heat). Since 1850, the concentration of atmospheric CO_2 ([CO_2]) has increased from 280 parts per million (ppm) to 427 ppm [2] and that of methane has risen 2.5 fold. Despite

repeated warnings and international negotiations, GHG emissions increased by 12.7% from 2010 to 2023 [3], and atmospheric [CO_2] rose from January to April 2024 faster than during the same time period in any previous year [4] (see Figure 1). Resulting energy gain is raising the average surface temperature of the whole Earth, and the 2015 Paris Conference of the Parties (COP) goal of limiting heating to 1.5 °C beyond preindustrial temperatures no longer seems attainable. [5] [6] Unless urgent action is taken, temperatures will rise 2.7 °C or more by 2100. [7] However, this may well be a gross underestimate as multiple positive feedback loops will accelerate global heating. As ice and snow melt, there is less to reflect solar radiation back into space (albedo effect), meaning that Earth's energy gain is rising. The presence of meltwater on ice surfaces also reduces albedo. Methane is released from stores in carbonate rocks and frozen tundra, and from fermenting wetlands. Global heating is driving an increase in frequency, severity and extent of wildfires, which release CO_2 and drive more heating. They also release soot (which lands on ice and snow and increases its melt) and carbon monoxide which extends the atmospheric half-life of methane. Tree surfaces also absorb and break down methane, but are lost in fires. Soils respire more with heat, releasing CO_2. Rainforests are becoming net emitters of CO_2. Worsening storms inject water vapour 19 km into the atmosphere where it acts as a GHG. Further, the state of weather systems will suddenly change, ocean currents will collapse, and the northern jet stream will move further towards the Arctic. Sudden acceleration in polar heating may occur as well (reviewed in [2]).

Climate Change Impacts Human Health

The World Health Organisation has described anthropogenic climate change as the "one of the greatest health threats for humanity", and stated that "we are facing an unprecedented crisis" .[8] Global heating will soon mean that 18% of the Earth's surface currently occupied by humans will have temperatures greater than the Sahara, rendering them largely uninhabitable. Heat related illness will be more common, and working outdoors (e.g. in agriculture) will become

increasingly hard in many places. Even prior to the record heatwaves in June of 2024, record-breaking extreme heat events were on the rise and impacting health. Adults older than 65 and infants younger than 1, for whom heat waves are associated with the most morbidity, are now exposed to twice as many heatwave days per year as compared to the years between 1986 and 2005. [9] A 2021 study extracted data across 43 countries from 1991-2018 and illustrated that more than one third of heat-related deaths were attributable to anthropogenic GHG emissions. [10] Rises in temperature, changes in rainfall, and extreme weather events will disrupt global food supply. Sea level rise will lead to loss of land and to salt water contamination, further impacting food production and associated health. Respiratory health will be impacted by particulate and gaseous pollution from land dissection and fires, and by changes in pollen volume and allergenicity. Increases in vector-borne diseases (as pathogen and vector distribution are affected by climate) will occur. Mental health will suffer and, together, such effects will displace growing numbers of people affected by forced displacement/migration. [9] [11]

The economic impacts of climate change are dramatic and accelerating, and will soon impact human health and survival. Global annual losses of $1.3 trillion have resulted in the last decade and the European Union (EU) lost EUR 650 billion due to climate extremes from 1980 to 2022, classifying climate change as a national security threat. Lloyds of London warn of a 1:300 chance of a $17.6 trillion impact on the global economy within the next 4 years, and global actuaries that ‘the economy may not exist at all’ without immediate transformative action (reviewed in [2]).

Every citizen, employer and government thus has a duty to act immediately to dramatically reduce GHG emissions.

Personal Actions

We all have a duty to act. Doing so reduces GHG emissions- but also moves markets, changes corporate behaviour, and creates a permissive environment into which politicians can move, stimulating productive and helpful positive feedback loops. However, uncertainty as to what action to take is prevalent and paralysing. [12] Figure 2 outlines personal actions which we can and must all take today. [13]

Climate Change and Healthcare

The healthcare sector is key to action. It is responsible for 4.6% of global GHG emissions- 56% of this coming from the United States, China, and the European Union. [14] In the United States, healthcare accounts for 10% of national emissions. Institutions, organisations, representative bodies and healthcare charities must all implement the same 'personal actions' (Figure 2). The carbon cost of all healthcare and research pathways must be reduced. But healthcare also accounts for >10% of world domestic product- so moving its spend could have transformative leverage. Healthcare institutions of all sorts (including charities, healthcare providers and companies) must engage and motivate their staff and those they represent, educating and informing them and encouraging them to act.

To ensure that action is effective, realistic and well-planned approaches are necessary. For example, changing two things in a department at a time will be more effective than multiple small changes that lead to confusion and frustration and that make impact difficult to measure. In most cases, carbon saving will also result in cost saving and improved patient care- improving the triple bottom line of sustainable healthcare (Carbon, Cost, and Care.)

We should also support mandatory reporting of GHG emissions by healthcare organisations and companies in all supply chains. This should include emissions from Scope 1 (from burning fossil fuels directly [e.g. gas boilers, volatile anaesthetic agents vented), Scope 2 (emissions resulting from power generated elsewhere) and Scope 3 (products or processes or actions commissioned- such as medical equipment manufacture, or patient travel). Reporting and tracking emissions is key to understanding the true cost of a treatment/ product and can influence choices and processes for the better. An 'E-liability method' can essentially allow emissions to be bought and sold with a product/service through the supply chain. [15] Deployed in the healthcare industry, this would force a reduction in life-cycle product and treatment emissions, driven by consumers and the market. This would include drug and equipment manufacturers as well as hospital buildings and sites. Collaborating with all partners, from energy suppliers to medicine suppliers, will enable effective industry wide change, where methods of accounting and emission reduction will also be used by non-healthcare activities as many paths are shared, thus initiating global action.

The Anaesthetist and Climate Action

Anaesthesia providers are leaders in patient safety and, for this reason, should likewise lead on action to reduce GHG emissions. Guidelines such as that from the World Federation of Societies of Anesthesiologists [1], emphasise the professional and personal actions they should take.

Even with additional guidelines published, a study Australian anaesthetists identified education as being paramount in supporting action: lack of understanding regarding the urgency of action needs to be overcome along with the lack of familiarity with alternative, sustainable practice. [17] This can be done on an international, national and departmental scale with existing best practice disseminated and promoted. National exams and syllabuses from a medical school to a

specialist training level should include carbon considerations. Departmental and (inter)national meetings should be used to educate and empower. Research into safe low-carbon anaesthetic practice should be supported.

Savings in emissions can be made by promoting public health measures: low-carbon living (plant-based diets, active transport, clean air) reduce sickness and related GHG emissions from healthcare. Perioperative pathways should minimise unnecessary travel and tests, and outcomes should be optimised to reduce complications, length of stay, and the GHG emissions associated with excess care requirements. These actions, and others, are explored in greater detail below.

Use of Volatile Inhalation Anaesthetic Gases

Some anaesthetic gases deplete atmospheric ozone. Many - especially desflurane and nitrous oxide- are also very powerful GHGs. High-flow volatile gas anaesthesia is the most environmentally damaging form of anaesthesia as the majority of volatile gases are released directly into the atmosphere after use and the waste phase of these gases accounts for 95% of anaesthetic gas emissions as in vivo metabolic break-down of these gases is low. [18] One hour of Desflurane use has the global heating action equivalent to the emissions of driving 200-400 km, whereas one hour of sevoflurane use is equivalent to driving 5-10km. [19]

There have thus been multiple calls for avoiding desflurane and nitrous oxide [20, 1] Many departments around the world have responded by alerting practitioners of high flow gas use, providing clear instructions on how to minimise gas use, and producing localised pre-digested literature reviews and summaries. [17] For example, Leeds Teaching Hospital NHS Trust in the UK has reduced desflurane use and subsequently reduced their whole Trust's carbon emissions by 3.9%. Some UK Trusts have even managed to phase out desflurane fully and, in 2023, Scotland became the first country to ban the use of desflurane at the national level. [21, 19]

Other recent guidelines include recommendations to decommission centralised nitrous oxide (which is a highly inefficient delivery system) and replace it with portable canisters (which are less prone to leaks to the atmosphere). [22] See Figure 3 [23][24] below for gas comparisons.

TIVA

Multiple guidelines emphasise the importance of using techniques such as regional anaesthesia and total intravenous anaesthesia (TIVA), where appropriate, that completely avoid inhalational agents and which can be associated with lower GHG emissions even when accounting for differences in disposable materials. [25] Lifecycle carbon impact analysis shows that TIVA is associated with significantly lower GHG emissions than desflurane and sevoflurane in similar procedures (3.2 kgCO_2e per 7 hour anaesthetic versus 820.2 and 69.9 respectively)[26], even when plastic production emissions of TIVA are included in assessment. While TIVA is not an entirely green alternative, it is significantly more sustainable in terms of GHG and direct contribution to the climate crisis.

TIVA may have other advantages: post-operative recovery is easier, with a higher recovery quality score, lower incidence of delirium and postoperative nausea being recorded across multiple studies. [27] Therefore, when education in alternative practice and use of TIVA or regional anaesthesia is promoted, the triple bottom line is improved.

Low Fresh Gas Flow

When analysing the environmental impact of the type of gas used, however, we must consider the amount of gas used and also its potency in both clinical and environmental terms. NO_2 is less potent as anaesthetic gas than is isoflurane, meaning that more is required, and that NO_2 is overall more environmentally damaging than isoflurane despite having a smaller global warming potential (GWP- a measure of energy trapped by a gas when compared to CO_2).[28] The term

'CO_2 equivalent (CO_2e)' refers to the number of metric tons of gas with the same GWP as one metric ton of CO_2 gas. Desflurane, acknowledging clinical efficacy and realistic use, has a CO_2e 25-45 times higher than that of isoflurane and sevoflurane respectively, whilst that of NO_2 is 10 and 20x higher respectively. Historically, manufacturing labelling in the United States recommending against low fresh gas flows has been a barrier to their adoption. The origins of the labelling stem from studies on Compound A, a chemical breakdown product formed by sevoflurane that is nephrotoxic in laboratory animals. Lower fresh gas flow rates and older formulations of CO_2 absorbents are associated with higher Compound A concentrations. However, numerous studies in humans have found no evidence of nephrotoxicity in humans at lower flow rates. [29] A recent statement by the American Society of Anesthesiologists called the FDA-approved labelling "dated and not supported by current research". [30]

Reducing fresh gas flows (FGF) to less than 1.0 L/min during the maintenance phase of anaesthesia is safe and simple given that the circle breathing system is designed to allow for the rebreathing of exhaled anaesthetic. Despite the fact that lifespan of the CO_2 absorbent is reduced [31], low FGF is associated with cost and carbon savings while preserving patient warmth and reducing respiratory tract water loss. [32] The provider must, however, be aware that changes in concentration of oxygen and agent delivery will occur more slowly with delivery at a lower rate.

Equipment

Where energy is derived from renewable sources, reusable equipment is less climate damaging than single-use equipment as sterilisation and recycling processes do not increase life cycle emissions substantially. [33] This is demonstrated with reusable rigid laryngoscopes, laryngeal mask airways, monitors, and plastic material. [1] In one total life cycle analysis, single-use plastic laryngoscope handles generated an estimated 18 times more carbon emissions, and the

single-use tongue blades generated 6 times more emissions then their reusable counterparts. [34] Concerns about infection are common, but not supported by evidence. [35] Due to the increase in the energy intensive activities such as cleaning and sterilising, the calculation generally shifts more in favour of reusable supplies in countries with higher proportions of renewable sources of electricity. [36] The production of intravenous medications themselves can also have a considerable footprint and can vary greatly depending on the specific medication. [37]

To reduce costs and carbon emitted, ensuring equipment is up to date, efficient and leak-proof is key. Carbon and cost savings can be made when health finance education is increased. A study in California found that, for a specific neurosurgical department, unused supplies were worth on average $653 per procedure. [38] While this may not be directly applicable to all departments, it indicates there is a level of wastefulness that suggests streamlining equipment packs for particular surgeries may be useful in reducing unnecessary waste.

Replacing single use with reusable equipment (e.g drapes, gowns, laryngoscopes, bronchoscopes) should thus be explored.

Efficiency

Reducing unnecessary anaesthesia is also key to reducing the practice's contribution to climate change.

Patient safety and needs are the core priority of providing healthcare. However, there are costs of unnecessary operations and tests; these are financial and environmental. Providing optimal clinically relevant and beneficial care does not require unnecessary testing or procedures to be done. Departments should support each other in acknowledging the unnecessary actions and

limiting them. The financial cost of low-value care involving unnecessary preoperative testing and subsequent cascade events is around US$ 18 billion annually in the USA. [39] Streamlining care and using standardised pre-op testing guidelines reduces unnecessary tests and has been shown to be effective in reducing GHG emissions associated with care. For example, implementing telehealth and standardised guidelines in one USA study was associated with a 9.6% reduction in GHG emissions (8.09 kgCO_2e) per elective spine surgery patient. [40] These findings can be applied to many surgeries and, on such a scale, can have a significant impact on GHG emission reductions.

Similarly, working on renewable energy contracts throughout supply chains is impactful as there are widespread and long-term benefits to the environment. This can be done on national or hospital scales. Milton Keynes Trust in the UK, for example, has invested in solar panels that now provide around 8% of the Trust's electricity, saving money, reducing carbon emissions and, due to associated improvements in estate infrastructure, improves patient care as the environment is easier to control. [41]

Conclusion

The climate crisis is a global threat to human health and survival. Action must be taken in personal and professional capacities. Making informed decisions regarding diet, transport, money and products can transform lives. Discussions, education and clear action, can transform workplaces. Together, these positive changes will mitigate climate disaster. In addition, most actions have positive health implications and improve the triple bottom line of sustainable healthcare, which regards cost of care, carbon emissions, and care quality. Healthcare requires a vast range of action, from changing energy supply; process, practice and procurement and food supply. Everyone must act- anaesthetists included.

Abstract

Purpose of review:

Climate change is the biggest threat to human health and survival in the 21st century. Emissions associated with healthcare contribute to climate change and there are many personal and professional actions that can reduce carbon emissions. This review highlights why action is necessary and what anaesthetists and healthcare workers can do.

Recent findings:

Encouraging continuing research regarding sustainable anaesthesia and expanding education at all levels to include climate action is key. Professionally, actions include limiting use of single-use equipment, reducing reliance on volatile gas inhalational anaesthesia, and adopting low fresh gas flow techniques. Personal actions such as climate-conscious travelling, spending, and eating are important, especially when shared to create climate positive movements.

Summary:

This article shows that, while patient safety and quality of care must remain healthcare's top priority, considering the climate implications of care is part of that duty. Many actions that reduce the carbon impact of care simultaneously improve the quality of care and reduce financial cost. More research into sustainable healthcare is needed. Departments and hospitals and must create environments in which climate conversations are welcomed and can result in positive advancements.

Keywords: Sustainable healthcare, Climate action, Sustainable anaesthesia

Key Points

- Immediate climate action at pace and scale is essential.

- Such action should be personal, professional and political.
- Personal actions include making conscious diet decisions, such as moving to local, seasonal, plant-based diets, transport decisions, prioritising active travel to public transport to car journeys and plane journeys, and money decisions, such as switching to sustainable banks and spending money wisely.
- Professional actions, especially in anaesthesia capacities, range from choice of anaesthetic, use of equipment, streamlining care, are often environmentally beneficial as well as providing financial benefits and improving quality of care.
- There are many possible actions and starting somewhere is important, as well as stimulating conversations, education and research into this vital aspect of the future of healthcare.

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2. Financial support and sponsorship

Conflicts of Interest: None.

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