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GUIDELINES

European Society of Anaesthesiology and Intensive Care consensus document on sustainability

4 scopes to achieve a more sustainable practice

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Climate change is a defining issue for our generation. The carbon footprint of clinical practice accounts for 4.7% of European greenhouse gas emissions, with the European Union ranking as the third largest contributor to the global healthcare industry's carbon footprint, after the United States and China. Recognising the importance of urgent action, the European Society of Anaesthesiology and Intensive Care (ESAIC) adopted the *Glasgow Declaration on Environmental Sustainability* in June 2023. Building on this initiative, the ESAIC Sustainability Committee now presents a consensus document in perioperative sustainability. Acknowledging wider dimensions of sustainability, beyond the environmental one, the document recognizes healthcare professionals as cornerstones for sustainable care, and puts forward recommendations in four main areas: direct emissions, energy, supply chain and waste management, and psychological and self-care of healthcare professionals. Given the urgent need to cut global carbon emissions, and the scarcity of evidence-based literature on perioperative sustainability, our methodology is based on expert opinion recommendations. A total of 90 recommendations were drafted by 13 sustainability experts in anaesthesia in March 2023, then validated by 36 experts from 24 different countries in a two-step Delphi validation process in May and June 2023. To accommodate different possibilities for action in high- versus middle-income countries, an 80% agreement threshold was set to ease implementation of the recommendations Europe-wide. All recommendations surpassed the 80% agreement threshold in the first Delphi round, and 88 recommendations achieved an agreement >90% in the second round. Recommendations include the use of very low fresh gas flow, choice of anaesthetic drug, energy and water preserving measures, ''5R'' policies including choice of plastics and their disposal, and recommendations to keep a healthy work environment or on the importance of fatigue in clinical practice.

Executive summaries of recommendations in areas 1, 2 and 3 are available as cognitive aids that can be made available for quick reference in the operating room.

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Introduction

Climate change is a defining issue for our generation. The carbon footprint of clinical practice accounts for 4.7% of European total emissions of greenhouse gases (GHG), and the European Union ranks as the third largest contributor to the global healthcare industry's footprint, with a share of 12%, after the United States (27%) and China (17%).[1,2]

Despite increased climate change awareness, GHG emissions have continued to rise rapidly in the last decade.[3] Even though the COVID-19 pandemic resulted in a temporary drop in fossil fuel and industry emissions, they rebounded by the end of 2020.[4] Earth temperature has risen 1.2°C since the beginning of industrial age, and it is expected to exceed a 1.5°C increase by 2030.[5] In this context, the Intergovernmental Panel on Climate Change (IPCC) report depicts 5 different scenarios with significantly different outcomes depending on how these temperatures will be controlled in the near future. Therefore, a 50% reduction of GHG emissions in the upcoming decade is urgently needed.[6]

In response to the urgency for climate action, the EU increased its climate ambition through Regulation (EU) 2021/1119 (the European Climate Law), which was adopted in 2021. The climate law establishes a binding net GHG reduction target of at least 55% by 2030 compared to 1990 and EU climate neutrality at the latest by 2050.

Sustainability in anaesthesiology and intensive care

Sustainability in Anaesthesiology and Intensive Care is a new topic for most anaesthesiologists around the world. Postgraduate training on this subject is scarce, and pregraduate education in medical schools is nearly nonexistent. According to the World Health Organization, an environmentally sustainable healthcare system should 'improve, maintain or restore health, while minimizing negative impacts on the environment'.[7]

Recognising the importance of urgent action, the Sustainability Committee of the European Society of Anaesthesiology and Intensive Care (ESAIC) created the Glasgow Declaration on sustainability in anaesthesia and intensive care[8] in June 2023. This Declaration presents a shared European perspective of what is feasible and achievable within environmental sustainability. It builds on the existing Helsinki Declaration for Patient Safety[9] and is intended as a guide for countries across Europe to build into their own healthcare plans. Inspired by the upgraded climate law of the EU, the ESAIC Sustainability Committee aims to provide a consensus document in perioperative sustainability that can be applicable in all its member countries.

There is only one available international consensus statement in perioperative sustainability, developed by the World Federation of Societies of Anaesthesiologists and published in September 2021.[10] This document, based on expert opinion recommendations from anaesthesiologists worldwide, does not necessarily reflect the reality of European Countries.

Since there is a lack of studies that can provide solid evidence-based recommendations, further research is warranted to create high quality evidence, and in the meantime, we must rely on expert opinion consensus.

The goal of this consensus document is to:

1) Raise awareness on the relevance of achieving a more sustainable clinical practice.
2) Improve education by providing updated facts and evidence.
3) Give recommendations that allow anaesthesiologists to make informed decisions balancing patient safety and planetary health considerations.

Scopes of action

The healthcare industry carbon footprint can be divided into three major scopes: scope 1 refers to direct emissions, scope 2 represents energy related indirect emissions, and scope 3 refers to the supply chain and waste management. In this document we have added a fourth scope that deals with the wellbeing of healthcare professionals and the carbon footprint derived from transport to and from hospital.

Volatile anaesthetic agents belong to the first scope (direct emissions), and they are responsible for roughly 0.10% of global GHG emissions. Based on atmospheric sampling of volatile anaesthetics, their accumulation is increasing, particularly desflurane[11] which was identified as the most carbon intensive.[12] Whilst these are a seemingly small contribution to global emissions, inhaled anaesthetics account for 5% of hospital CO_2 equivalent (CO2e) emissions, and up to 50% of perioperative department emissions in high-income countries.[11–14] The use of these anaesthetics agents is directly within the control of anaesthesiologists, with often more sustainable alternatives available. Thus, environmental stewardship is an important opportunity for GHG mitigation and professional sustainability leadership.

Scope 2 represents energy related indirect emissions. While hospital heating, ventilation and air conditioning systems (HVAC) – which include anaesthetic gas extraction systems – have been shown to be responsible for 52% of the energy needs of inpatient health-care facilities, MacNeill *et al.* found that HVAC energy demands comprised 90–99% of overall operating room (OR) energy use, reflecting these areas as one of the most resource demanding.[12] Energy conservation efforts should therefore focus on HVAC system management. Moreover, the energy source for each hospital must be taken into account in order to properly estimate local emissions. Centres which obtain energy from renewable sources like hydropower or photovoltaic will have lower carbon footprints than centres whose energy source is based on fossil fuels.

Scope 3 refers to the supply chain and waste management. In the United Kingdom, 65% of total greenhouse gas emissions within the healthcare industry belong to this scope. Between 75% and 90% of all hospital waste is comparable to domestic waste and most of it has the potential to be recycled. Therefore, 5R policies (Table 1) are the key elements of this scope. Nevertheless, staff shortages, supply chain disruptions, and lack of education are potentially the main culprits of the under-implementation of these policies.

Scope 4 lies beyond the environmental rationale of these recommendations. Nevertheless, we believe it belongs to a wider sustainability concept, since it aims to improve the psychological and self-care side of our clinical practice. Improving our wellbeing and being able to identify and deal with burn-out are some of the cornerstones of this scope. Moreover, transport related carbon footprint from patients and healthcare professionals is also discussed in this section.

Patient's perspective

Patients undergoing surgery highlight the need for environmentally friendly interventions if these are safe and effective. They also agree that health services should promote their own efforts to reduce the carbon footprint in perioperative medicine and, to a lesser extent, that patients should be empowered to make choices to reduce the carbon footprint of their operation as part of the consent process.[15]

Methodology

Given the urgent need to cut global carbon emissions and the scarce evidence-based literature regarding perioperative sustainability, to commit to the European Commission goal of becoming a carbon neutral continent by 2050 at the latest ('European Climate Law'[16]), our methodology is based on expert opinion recommendations after researching available data, national sustainability recommendations, and local or national protocols on this matter.

Table 1 5R policies

Policy	Example
Reject	Avoid using unnecessary products or devices Avoid waste generation
Reduce	Draw up all the chosen product into one or more syringes before opening a new container (e.g. drug ampoules in paediatric anaesthesia)
Reuse	Avoid single-use appliances when applicable in compliance with local safety and hygiene protocols
Recycle	Make a recycling protocol according to local needs (plastics, metal, glass, cardboard)
Repair	Implement protocols for proper device maintenance. Ask for adequate post sale maintenance service.

Panel members

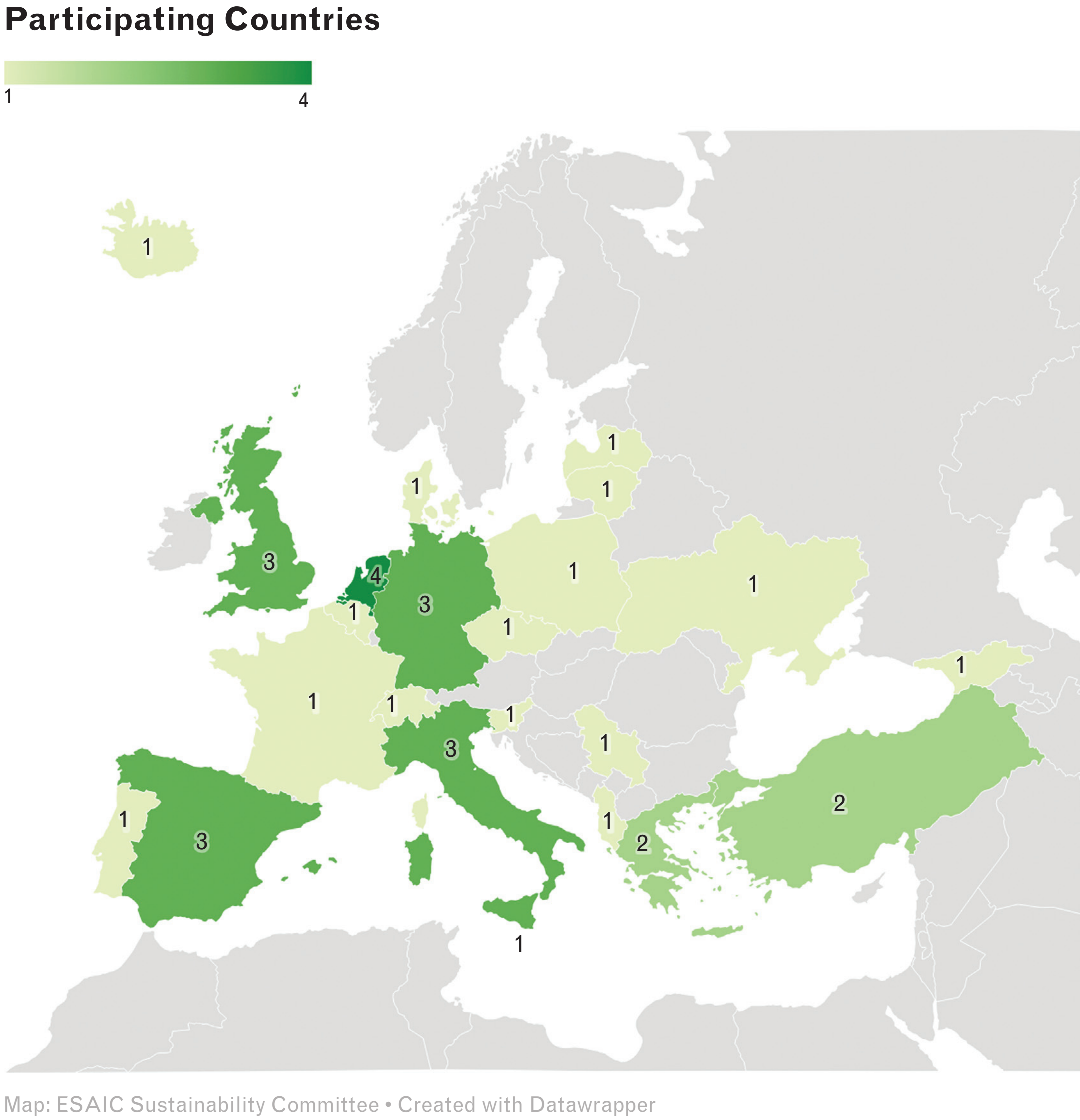
The panel of experts was selected from the ESAIC Sustainability Committee and a wide range of relevant stakeholders who had proven previous involvement in sustainability initiatives and had current expertise on the field. These constituted the Core Working Committee (CWC) with 13 experts in sustainability and 2 experts in guidelines development and methodology (Supplemental File 1, http://links.lww.com/EJA/A904) from 9 different countries. The CWC drafted a number of recommendations that underwent a Delphi validation process. The Delphi Validation Committee was selected during the months of October to December 2022 with the help of the national representatives who make up the National Anaesthesiologists Societies Committee at ESAIC (NASC). Each NASC representative could appoint one Delphi representative who must be either the chairperson of a national sustainability committee or, in the absence of such a committee, a recognised national sustainability expert. After this process, 36 experts from 24 different countries were chosen to participate in the Delphi Validation Committee (Fig. 1 and Supplemental File 2, http://links.lww.com/EJA/A905).

Recommendations

The scope of the recommendations (Fig. 2) involves perioperative carbon footprint (scopes 1, 2 and 3), and wellbeing and self-care enhancement (scope 4).

As described above, we selected four main areas to prioritise: 'Anaesthetic drugs', 'Energy recommendations', 'Waste and supply' and 'Wellbeing and transport'. Each scope included a rationale to frame the current situation followed by a set of recommendations for each area. To facilitate the implementation of the recommendations, we discuss the most important potential barriers detected that could deter the implementation of these recommendations, and we propose some outcomes measures in the short term that can facilitate the change towards a more sustainable healthcare system. We include some of these outcome measures as "impact measures" to help quantify, in an objective manner, the effects of the different strategies described in migrating to environmentally green operating rooms. Implementation of the recommendations are the ultimate goal of this document and by monitoring these impact variables, we can easily benchmark the starting situation and observe how changes are assimilated and how the healthcare transformation towards sustainability is progressing. These impact variables can also be used in future updates of this document to assess the development of the perioperative sustainability status and to readapt strategies if needed.

Fig. 1 The 24 participating countries in the Delphi Validation Committee. Numbers represent the number of representatives *per* country in the Delphi Validation Committee. Image created with Datawrapper.



Internal validation process

The document was created in an iterative process that included the Core Working Committee (CWC), the European Society of Anaesthesiology and Intensive Care (ESAIC) Board of Directors (ER, WB) and the ESAIC Guidelines Committee (CR, PK). The CWC included all members from the ESAIC Sustainability Committee and ten external experts with in-depth expertise in sustainability and evidence-based medicine (Supplemental File 1, http://links.lww.com/EJA/A904). A total of four meetings were held virtually, and a final in-person meeting took place during the Euroanaesthesia 2023 Congress in Glasgow.

The CWC collected the available evidence and created a draft preliminary recommendations document during the months October to December 2022. This draft was then submitted to the ESAIC Board for comments (February 2023). Taking these comments into account, the final document was then created and approved by the CWC and the ESAIC board (March 2023).

Delphi validation

The external Delphi validation consisted of a two-step voting process, and was held online using REDCap electronic data capture tools hosted at La Paz University Hospital (Madrid, Spain). REDCap (Research Electronic

Fig. 2 Scopes of recommendations.

Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing an interface for validated data capture and allowing for audit trails and for tracking data manipulation.

A total of 90 recommendations were submitted for voting. Given that ESAIC has middle and high-income countries among its members, initially, we accepted an 80% agreement threshold in order to ease implementation of the recommendations Europe-wide. The first Delphi round took place in May 2023 and consisted of a Yes/No decision-making process for each proposed recommendation. For those recommendations with a negative answer, a free-text box was available for members to enter comments so that the rationale for disagreement could be assessed and alternative wording suggested. After the first Delphi round, all recommendations reached the 80% level of agreement with only six having less than 90% agreement. During the Euroanaesthesia 2023 Congress in Glasgow (June 2023) an on-site meeting took place where the CWC proposed new wording for these six recommendations. Shortly thereafter the second and final Delphi voting round took place in June 2023 to reconsider these 6 recommendations, and after this only two remained below 90% agreement.

Scope 1

All inhaled anaesthetic drugs are potent greenhouse gases that exert their global warming effect in the troposphere, by absorbing and later reflecting infrared thermal radiation back to Earth, hence interfering with the main cooling mechanism of our planet.[14]

Volatile anaesthetic agents are highly inert molecules that are only minimally biotransformed, and are thus released into the atmosphere largely unchanged after being administered intraoperatively or in the intensive care unit. These drugs include nitrous oxide and the halogenated gases: sevoflurane, desflurane, isoflurane, enflurane and halothane. Sevoflurane and desflurane in particular have shown ever-increasing consumption since their market launch in the mid-1990s, with increasing concentrations being measured in the atmosphere, including above Antarctica and other remote areas.[11,17]

The first publication showing the impact of volatile anaesthetics on global warming was published in 1989.[18] Anaesthesiologists in Europe primarily use sevoflurane (85%), followed by desflurane (10%) and in rare cases isoflurane (3%).[19] There is also some use of halogenated drugs for sedation in intensive care medicine, namely sevoflurane and isoflurane, although desflurane has also been tested.[20] Globally, these three most commonly used volatile anaesthetics are estimated to contribute 0.02–0.1% to global warming, with desflurane alone accounting for 80% of the climate impact.[14] Moreover, nitrous oxide (N_2O) and isoflurane have ozone-depleting properties.

The climate warming effect of a substance, commonly referred to as Global Warming Potential for a timeframe of 100 years (GWP_{100}), is determined by the atmospheric lifetime and the atmospheric reflection range of infrared radiation. Compared to CO_2, which is the reference greenhouse gas with a GWP_{100} of 1, volatile anaesthetics have significantly higher GWP_{100}: sevoflurane 144, N_2O 298, isoflurane 510, and desflurane 2540.[21] Nevertheless, atmospheric lifetimes of inhaled anaesthetics are significantly shorter compared to predominant greenhouse gases such as methane or N_2O, that is why many scientists consider it more appropriate to measure the GWP of volatile anaesthetics in a 20-year timeframe (GWP_{20}),[22,23] which would result in a GWP_{20} impact of: sevoflurane 508, isoflurane 1800 and desflurane 6810.[21] Moreover, when evaluating the carbon footprint of the direct emissions of inhaled anaesthetic agents, it should be considered that different gas concentrations are required to achieve an adequate anaesthetic level.[23] Finally, the inclusion of the fresh gas flow is also necessary in order to correctly determine the climate-warming effect of each anaesthetic procedure. The gas consumption in the induction phase is usually significantly higher, and should thus be chosen with care in the future. In order to assess the climate-warming effect of our practice, all of these parameters need to be taken into consideration. For example, the CO_2 equivalent footprint over a time scale of 20 years reflecting the clinical use of volatile anaesthetic agents (1 h anaesthesia with a fresh gas flow of 0.5 l min^{-1}) would be: sevoflurane 3980, isoflurane 4970, and desflurane 69 490.[23]

Nitrous oxide, although having a low radiative efficiency, has a tropospheric lifetime of 110 years which accounts for its GWP_{100} of ~300. Furthermore, due to its low potency, it is used in relatively large quantities in analgesia/anaesthesia, and there is probably an underestimation of role of N_2O because it is used frequently outside the OR, such as in maternity wards, emergency services, dental offices, wound centres, etc.[24] Anthropogenic N_2O generation, including industrial and medical use, is at present responsible for most ongoing ozone depletion.[25] The global contribution of the perioperative use of N_2O is estimated to be 1 to 3% and should not be ignored,[11] although it can account for up to 5% of anaesthetic practice, especially in the Middle East and Africa.[19] Isoflurane also has an ozone depletion potential effect but as its tropospheric lifetime is short, the effect is minimal.[26]

Mitigation strategies

There are different commercial devices available that allow for inhaled anaesthetic drugs adsorption (Vapor Capture Technology, VCT) using activated charcoal canisters, hence avoiding their atmospheric release from the operating rooms. These adsorbed gases can either be destroyed or be subject to a desorption process allowing for a second use and preventing further *de novo* synthesis. Nevertheless, second gas use has only been granted for sevoflurane in Germany and Austria, and for desflurane and sevoflurane in Canada. Moreover, the efficiency of these promising technologies, which ranges from 25% to 70% according to a small number of investigations,[27,28] some of which are methodologically contested, needs to be further studied with independent life-cycle evaluations. Hu, Pierce and colleagues assessed the life cycle analysis of VCT for sevoflurane, desflurane and isoflurane compared with propofol under optimal conditions (minimal fresh gas flow, energy-saving production, and avoiding N_2O). They published that while the carbon footprint of desflurane is still higher than propofol, the carbon footprint for sevoflurane or isoflurane is similar to total intravenous anaesthesia with propofol, provided that sevoflurane is manufactured from hexachloroacetone fluorination, instead of tetrafluoroethylene as the raw material – the most energy saving way for production.[27] Nevertheless, the use of VCT should always come together with the lowest possible fresh gas flow.

Another possibility is the photochemical destruction of inhaled anaesthetic agents with UV light. Under optimal conditions of minimal fresh gas flow rates, the removal efficiencies of these gas destruction systems could reach a reduction of sevoflurane by 85% and desflurane by 64%.[29] With all of these innovative approaches, however, it should be borne in mind that patients still exhale anaesthetic drugs in the recovery room, which can even account for up to 75% of the total inhaled anaesthetic.[30] Regarding N_2O use in obstetric anaesthesia, despite some centres which are equipped with catalytic destruction devices (mobile or central units) showing up to a 50% reduction in GHG emissions,[31] pipeline and Schrader valve outlets account for a significant amount of N_2O loss. Epidural and remifentanil PCA provide superior analgesia at a fraction of the carbon footprint but, unfortunately, they are not available in all birth settings. For epidural analgesia, the disposables required for insertion are responsible for over 70% of emissions, the largest single contributor being the single-use sterile gown. Changing to reusable gowns and drapes and streamlining packs to limit waste would reduce the carbon impact of epidural analgesia. Remifentanil PCA has a more favourable carbon footprint but is not routinely used in the majority of delivery suites probably due to the additional monitoring required and the fact that it is a less effective than epidural analgesia.[32]

Regulatory measures

Concerns about global warming caused by fluorinated gases have increased significantly in recent years. The

''Kigali Amendment'' to the Montreal Protocol was adopted in 2016, banning the use of hydrofluorocarbons (HFCs) in refrigerants, solvents, aerosol propellants, fire-fighting foam, and in the foam industry worldwide by 2030. Excluded from these regulations are military and medicinal substances, such as inhaled anaesthetics and metered dose inhalers. However, in April 2022 the European Commission proposed an update to the regulation of fluorinated greenhouse gases, including the recommendation to ban the use of desflurane throughout Europe from January 1, 2026.[33] If approved, this would imply that, from 2026 onward, desflurane may only be used if a clear medical indication is seen and documented, and no other anaesthetic can be used. Moreover, this proposed new directive acknowledges that all inhaled anaesthetic drugs have different levels of global warming potential, and are thus in principle subject to regulation, although desflurane is the only anaesthetic agent surpassing the regulatory threshold of GWP_{100} 2500.

Propofol footprint

Propofol has a global warming potential 4 orders of magnitude lower than volatile anaesthetics[34] since its by-products are not released into the atmosphere, but into aquatic eco-systems. The propofol contribution to GHG emissions comes from the energy infusion pumps and plastic-made infusion sets require to deliver it intravenously, but also from unused propofol incineration processes needed to prevent water pollution.

Propofol is extensively metabolised within the body and mainly excreted through urine, approximately 88% as inactive metabolites and <1% unchanged.[35] Nevertheless, propofol has demonstrated toxicity in aquatic organisms, and measurable quantities are present in drinking water and fish tissue,[36] reflected in a hazard score of 4 out of 10, indicating low environmental risk.[37,38] However, wastewater drug sampling performed in France and Sweden provided conflicting results about propofol water pollution on urban sewage effluents.[39,40] Moreover, despite propofol manufacturer recommendations to burn unused propofol, studies have shown that 32–49% is disposed of as waste,[41,42] and not all institutions incinerate unused propofol. Therefore, more comprehensive studies on the environmental impact of propofol are still needed. Furthermore, the use of TIVA in institutions where it is not already widely used requires training and equipment procurement.[42,43]

No recommendation could be reached on the use of 2% over 1% propofol due to a lack of robust trials designed to look specifically at sustainability effects: 2% propofol is pharmacologically identical to 1% in terms of efficacy and use, though patients have markedly lower lipid levels following the use of the 2% formulation.[44] This would imply that a lower lipid load is given during the case, which may translate into lower use of consumables (vials, syringes etc.) since a lower volume is required. This unconfirmed benefit needs to be weighed against the safety aspects of keeping different strengths of propofol and having multiple programmes for it on TIVA pumps. Any sustainability benefits would be more profound in longer cases (when the lipid benefits to the patient will also be greater), but from a pure sustainability perspective, while intuitively the use of 2% makes sense, there is a lack of specific robust evidence to confirm this is the case.

pEEG Monitoring

EEG-guided anaesthesia can reduce sevoflurane requirements in children undergoing general anaesthesia.[45] EEG monitoring allows direct visualisation of brain responses in real time and may allow clearer assessment of varying hypnotic requirements in patients of different ages and backgrounds, hence allowing for a tailored drug dosing.[45–47]

Recommendations:

1) In order to enhance the implementation of sustainability policies in your institution, name a sustainability lead / coordinator in your department (100% agreement).

2) Quality improvement initiatives to reduce inhaled anaesthetic drug consumption should be implemented in hospitals (97% agreement).

3) When administering inhalational anaesthesia, choose the agent with the lowest Global Warming Potential available (sevoflurane < isoflurane < desflurane) (94% agreement).

Impact measures:

- Annual gas consumption per year
- Annual gas consumption per anaesthesia-hours

Challenges of implementation:

- Time allocation to provide suitable information and training,
- Need for culture/practice changes.

4) Recommendation: The carbon footprint of total intravenous anaesthesia and of regional anaesthetic techniques are significantly lower compared to volatile anaesthetics and should be used whenever possible (94% agreement).

Impact measure:

- Propofol annual consumption
- Propofol annual consumption per anaesthesia-hours
- Rate of regional anaesthesia per procedure

Challenges of implementation:

- Monitoring depth of anaesthesia during total intravenous anaesthesia should be assessed by pEEG monitoring and performed under TCI capable infusion pumps when available.
- Regional anaesthesia is not possible in every surgical procedure.
- Uncertainty on other environmental impacts, (i.e. water pollution arising from manufacturing and disposal of these drugs, scarcity of raw materials for drugs, scarcity of monitoring or financial resources).

5) Recommendation: All halogenated drugs should be used with the lowest possible fresh gas flow (FGF) during the induction and maintenance phases of anaesthesia (94% agreement).

6) Recommendation: During the maintenance phase, FGF should be set to a minimum-flow ($< 0.5\ l\ min^{-1}$), whenever safe and technically feasible (100% agreement).

7) Anaesthetic drug requirements should be tailored according to depth of anaesthesia (pEEG) monitoring to avoid unnecessary gas or propofol consumption (91% agreement).

Impact measures:

- Hypnotics annual consumption
- Hypnotics annual consumption per anaesthesia-hours

Challenges of implementation:

- Technological availability issues (anaesthesia work station specifications, gas analyser sampling)
- Contraindications (hypermetabolic states, increased carbon monoxide production)
- Personal traditions and concerns for hypoxia or CO_2 rebreathing.
- Availability and training in pEEG monitoring.

8) Recommendation: Desflurane should be avoided and only used when strictly clinically indicated, and where there is not a valid alternative available. It has a 25 times higher carbon footprint than sevoflurane (83% agreement).

Impact measure:

- Desflurane consumption per year
- Desflurane annual consumption per anaesthesia-hours
- Desflurane clinical indication audit

Challenges of implementation:

- Raise awareness and improve education for anaesthesiologists so they are able to make informed decisions based on the best possible balance between patient and environmental safety.

9) Recommendation: Inhaled anaesthetic drugs recycling methods using VCT devices need to be further studied using independent life cycle analysis. Their circular economy endpoint, allowing for drug reuse, has a potential positive impact when used together at the lowest possible fresh gas flow rate (100% agreement).

Impact measure: Number of detailed life cycle analysis of each anaesthetic agent.

Challenges of implementation:

- Cost of VCT implementation.
- Further product procurement.
- VCT adaptation to different ventilators brands and models.
- National and European legislation about anaesthetic gases second use.
- Recycling Systems efficiencies need to be assessed.

10) Recommendation: Nitrous oxide should only be used when other alternatives are not available (100% agreement).

11) Recommendation: Hospital central gas delivery systems can still account for most nitrous oxide atmosphere delivery due to leaks, despite no actual clinical use. Current nitrous oxide central delivery systems should be decommissioned and they should be removed from future hospital plans. Bottled N_2O can be provided on demand when strictly needed (100% agreement).

12) Recommendation: Epidural analgesia or remifentanil PCA have better carbon profiles than nitrous oxide, and therefore should be offered in maternity wards according to local protocols (94% agreement).

Impact measure:

- Nitrous oxide consumption per year
- Nitrous oxide annual consumption per sedation-hours

Challenges of implementation:

- Midwives, paediatricians and emergency staff frequently use nitrous oxide autonomously

Behavioural change:

- Supplemental File 3, http://links.lww.com/EJA/A906 shows a clinical bundle to reduce the carbon footprint of anaesthetic practice in relation with scope one. It can be placed beside the anaesthesia workstation as a cognitive aid.

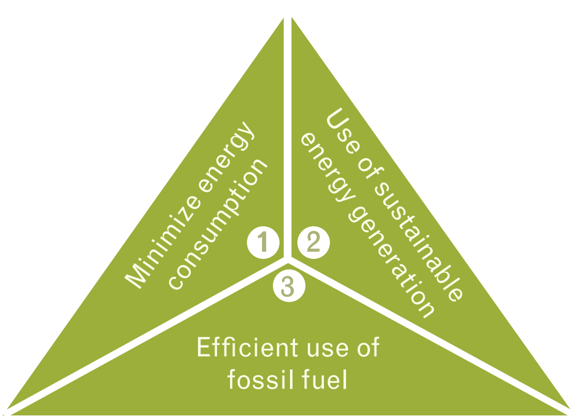
Scope 2

Energy consumption is one of the most relevant carbon emitters within hospital healthcare. Perioperative medicine is a resource-intensive health-care activity, requiring expensive equipment, sterilisation procedures, advanced operative technologies, and obligatory life support systems. These activities use considerable amounts of energy. A classical tool to reduce the environmental impact associated with energy consumption is to use the 'trias energetica' (Fig. 3). It focuses on: (1) minimising energy consumption, (2) a transition towards sustainable energy generation and (3) prevention of energy loss.

While hospital heating, ventilation and air conditioning systems (HVAC) have been shown to be responsible for 40% to 50% of the energy needs of inpatient health-care facilities, MacNeill and colleagues found that HVAC energy demands comprised 90% to 99% of overall operating theatre energy use.[12] Energy conservation efforts should therefore focus on HVAC system management. Additionally, the energy source for each hospital has to be taken into account in order to properly estimate local emissions. Centres that obtain energy from renewable sources, like hydropower, wind or photovoltaic, or even nuclear, will have lower carbon footprints than centres that base their energy source on fossil fuels. Lastly, preventing waste of energy generated with fossil fuels should also be cautiously considered, especially when designing new facilities. Proper insulation and introducing passive building concepts to retain heat can significantly reduce energy consumption and energy waste in clinical practice.[48]

Sustainable Development Goal (SDG) 6 is to ''Ensure availability and sustainable management of water and sanitation for all''. It covers all aspects of both the water cycle and sanitation systems, and the achievement of SDG 6 goals would contribute to progress with other SDGs, such as on health and the environment.[49]

Fig. 3 Trias energetica.



Water is at the core of sustainable development and is critical for socio-economic development, energy and food production, healthy ecosystems and for human survival itself. Water is also at the heart of adaptation to climate change.[49]

Water is also a rights issue. As the global population grows, there is an increasing need to balance all of the competing commercial demands on water resources, so that communities have enough for their needs.[49] Some concerning facts about water cycle are:

- 90% of natural disasters are water-related, including floods and droughts.
- 80% of wastewater flows back into the ecosystem without being treated or re-used.
- 2 billion people live in countries experiencing severe water stress.

Recommendations

1: Minimise energy consumption

HVAC optimisation

During theatre construction

- The use of a mixed generated flow within HVAC systems is more energy efficient than laminar flow[50] (94% agreement).
- Theatre air should be filtered and circulated back to the operating room (97% agreement).
- Variable speed drives are preferred to pump and fan systems (100% agreement).

System turn-down[12,14,51,52]

- HVAC systems should be set back to 6 Air Changes per Hour (ACH) when the operating theatres are not in use to reduce energy consumption, and re-establish standard ACH before new patients arrive (91% agreement).
- HVAC systems should be set back to a minimum during night-time and weekends, leaving some theatres ready for emergencies (94% agreement).
- Motion/occupancy sensors or radio-frequency identification (RFID) should be installed to optimise lighting and HVAC system activity (94% agreement).

- Impact measure: Energy consumption gap before and after implementation
- Challenge: Engineering and Infections controls approval

Heating/cooling[53]

- To reduce energy demands, set OR temperature within an 18–22°C range, provided that hypothermia prevention measures (e.g. warming blankets, warming fluid devices) and monitoring are in place.

Newborns are excluded from this recommendation (97% agreement).

- Burns Unit operating theatre optimum temperature range is 24°C to 30°C (97% agreement).
- Impact measure: Average theatre temperature gap per month before / after implementation
- Challenge: Engineering feasibility

Ventilation and humidity

- Appropriate clean room standards for procedures (depends on regulations) (100% agreement).
- Operating room relative humidity should be maintained between 30% and 60% at all times[53] (94% agreement).
- Impact measure: Average humidity gap per month before / after implementation
- Challenge: Engineering feasibility
- Operating room doors should be kept closed at all times to reduce temperature loss (97% agreement).
- Impact measure: Average OR temperature gap per month before/after implementation
- Challenge: Engineering feasibility. Behaviour change.

Lighting

- Operating room ambient and surgical lighting should be LED based (97% agreement).
- Impact measure: Energy consumption gap before/after implementation
- Challenge: Engineering approval

Other electrical equipment with power cables

- o Anaesthesiologists, surgeons and nurses should redesign sterile procedure trays to make them more efficient, hence requiring less time and energy for resterilisation (Lean surgical trays)[54] (100% agreement).
  - Impact measure: number of trays used and number of sterilisations per procedure before/after implementation
  - Challenge: Behaviour change
- o Consider the use of conductive fabric warming systems, which are more energy efficient than forced air warming blankets[55,56] (97% agreement).
- o Sterilisation is a high demand energy process, therefore sterilisers should be energy efficient (100% agreement).
- o Scavenging systems should be turned off at night and during weekends, except in operating rooms designated for emergency surgical procedures (100% agreement).
- o Automatic electronic switch off for computers and Wi-Fi networks should be available for nonoperational operating rooms during off-hours. If such automatic switches are not available, make sure that turning off the equipment is a task for the last person leaving the operating room before night shift or weekend starts (100% agreement).
- o Label equipment that can be turned off safely after use (100% agreement).
  - Impact measure: Energy consumption gap before /after implementation
  - Challenge: Engineering approval

Cordless electrical equipment

- o Rechargeable batteries are preferred over disposable ones (100% agreement).
- o If disposable batteries are used, they should be disposed of separately according to national regulations. Beware of devices that require disposable batteries. Remove them before disposal. (100% agreement).

- Impact measure: number of disposable batteries purchased before /after implementation
- Challenge: Economic and behaviour change

2: Use of sustainable energy generation

- Hospitals should have their own renewable energy production sources when feasible: photovoltaic, thermosolar and geothermal are readily available depending on the geographical location (91% agreement).
- Windows and natural light sources should be encouraged to reduce electricity lighting (97% agreement).
- Consider passive and intelligent systems to optimise energy consumption when designing new facilities[48] (97% agreement).

- Impact measure: Energy consumption gap before/after implementation
- Challenge: Engineer approval

3: Prevention of energy loss

- Insulation should be optimised when designing new facilities, or when major renovations are expected (97% agreement).
- Windows should be closed to prevent temperature loss, while providing passive filtered ventilation when possible (100% agreement).

- Impact measure: Energy consumption gap before/after implementation
- Challenge: Engineering approval and behaviour change

Water management

- Handwashing sensors at surgical sinks are both resource and cost saving, therefore should be available (97% agreement).

- Surgical hand rubbing is preferred over surgical hand scrubbing[57] (97% agreement).
- Reclaimed water rather than drinking water should be used for nonhuman use (cooling systems, warming circuits, or toilet flushing) (100% agreement).

- Impact measure: water consumption gap before /after implementation
- Challenge: Engineering approval and behaviour change

Behavioural change:

Supplemental File 4, http://links.lww.com/EJA/A907 shows a clinical bundle to reduce the carbon footprint of anaesthetic practice in relation with scope two. It can be posted by OR entrance / exit doors as a cognitive aid.

Scope 3

Waste management

Hospital care generates a large and diverse amount of waste. Regulated clinical waste includes sharps, pharmaceutical, biological and radioactive material. General waste is defined as anything other than regulated or clinical waste.[58–60] Hospital waste is responsible for approximately 1.0–4.2% of the nations' solid waste,[61] and 2.1% of annual GHGs emissions in high-income countries. Moreover, depending on the methodology and assessment criteria, scope 3 can account for 12–65% of total hospital greenhouse gas emissions.[12]

Between 75% and 90% of all hospital waste is comparable to domestic waste and most of it has the potential to be recycled.[62,63] According to the WHO, about 85% of hospital waste is nonhazardous, about 10% is infectious and the remaining 5% is noninfectious but dangerous.[64]

Operating rooms produce approximately 20–33% of all waste in a hospital, and general waste accounts for more than 50% of total OR waste. Interestingly, up to 25% of the latter is generated by anaesthesiologists.[65,66]

A significant, but variable, amount of waste is the result of time expired products and sterility breaches. During preparation for surgical procedures, OR nurses regularly open surgical packs and trays that may not be used later.[67] In addition to this, disposable surgical trays and packs often contain supplies or instruments that are not used because of surgeon preferences or specific needs.[67] When OR staff actively monitor the rate of unused material that becomes nonvalid for human use, this wastage and associated costs significantly diminishes.[68] A ''just-in-time'' stocking model seems appropriate to manage supplies, although supply chain disruptions may pose a significant risk. Therefore, for equipment stocking we propose a ''cautiously-in-time'' model for nonemergency clinical scenarios, which takes into account both the risks of unused items being discarded, and the lack of equipment due to supply chain shortages: this requires a thorough assessment of the existing supplies and their predicted rate of consumption in each institution.

Another major contributor to OR waste comes from prepackaged supply kits. Much of what is included in these supply kits is discarded as waste: these materials include sterile towels, sterile gloves, or disposable surgical gowns, which unduly contribute to generated waste.[68]

Drug use optimisation

The number of drugs prepared for ''in case of emergency'' scenarios which go unused is more than 50%.[69] The most frequently wasted drugs include ephedrine (60% of cases), succinylcholine (34%), and lidocaine (25%).

Propofol is an environmental hazard because it is not biodegradable, and it has demonstrated toxicity for aquatic organisms. Measurable quantities are present in drinking water and fish tissue. Propofol accounts for roughly 45% of wasted anaesthetic medication.[42,68]

Life cycle assessment

Life cycle assessment (LCA) is an assessment of a product or system throughout its life cycle, from cradle-to-grave. It includes several steps ranging from raw material extraction to manufacturing, transportation, use and waste management.[70–72]

Medical devices energy optimisation:

The European Commission approved an updated and simplified energy efficiency scale (A - G) starting March 2021 to classify electronic devices and appliances. Moreover, other data is shown such as noise level, yearly kWh consumption and water use.

Plastics in healthcare industry

Polyvinylchloride (PVC) and Polypropylene (PP) are widely used polymers in the healthcare industry. PP is highly thermal resistant and can withstand much higher temperatures than PVC, which has higher energy consumption and CO_{2e} emission than PP.[73] Moreover, many single use devices in anaesthesiology are made from PVC plastic (e.g., face masks, laryngeal masks), or diethyl-hexyl phthalate (DEHP), which is a compound added to impart flexibility to PVC-based products such as intravenous bags, tubing systems or endotracheal tubes. DEHP is labelled as a probable carcinogen and possible endocrine disrupter by the Environmental Protection Agency in the United States. Therefore, the US Federal Drug Agency recommends alternatives for infants, toddlers, and pregnant or lactating women. Hence, reusable devices produced mainly from silicone or PP have a more favourable carbon footprint and are recommended over PVC or DEHP products.[72–75]

Medical devices recommendations

1. Consider LCA information among the acquisition criteria of new medical devices or equipment during tender process (100% agreement).

2. Consider a "cautiously-in-time" industrial stocking model for nonemergency clinical scenarios to prevent items becoming time expired[68] (100% agreement).
3. If applicable, consider purchasing reusable or reprocessed equipment instead of disposable ones (94% agreement).
4. Avoid single use devices that do not provide a clear benefit in patient care (94% agreement).
5. Actively document wastage to encourage staff to reduce waste and associated costs (100% agreement).
6. Ask industry providers for energy efficiency labels for new electronic devices according to the European A–G scale (100% agreement).
7. Patient care monitors should allow for interoperability (eg universal USB docks and cables) in the workflow, especially during patient transport phases where different technologies and devices might be needed within the same process (87% Agreement).
8. Ask for PP or silicone reusable devices over PVC/DEHP (97% agreement).

- **Impact measures**

  - Number of ecological friendly (recyclable and reprocessed) devices purchased in one year.
  - Number of devices recycled and reprocessed.
  - Number of tender processes including LCA information among required criteria.

Challenges of implementation

- Education of the personnel and notification of the hospital managers about the importance of life cycle analysis of medical devices / equipment.
- Industry collaboration.

Waste recommendations (reduce, reuse, recycle):

1. Think twice before opening a sterile package, supply kit or any other product. (100% agreement).
   Do you really need to use a new product? Is it possible to continue using the device or materials that have already been used for the patient at hand?
   Reduce the amount of waste generated minimising the need for recycling, energy intensive treatment or disposal in landfill.[76,77]
2. Tailor supply kits according to local protocols and needs.
   Avoid unnecessary material and medication that will go unused (100% agreement).
3. In a case where multiple ampoules of saline are required to dilute medication, consider the use of an appropriate sized bag of saline (100% agreement).
4. Use reusable equipment and materials instead of disposables ones (94% agreement).
   A multitude of life cycle assessment studies for anaesthetic equipment including, but not limited to, laryngoscope blades and handles,[78] anaesthetic trays,[79] blood pressure cuffs[80] and needle containers[81] have shown that reusable equipment and materials reduce the carbon footprint of that product by 19% to 89%.
5. Appropriate waste segregation is crucial for reducing clinical waste and achieving a higher proportion of recycled waste (100% agreement).
   A common misconception is that all items that come into physical contact with a patient are classed as infectious and are thus inappropriately put in clinical waste bins. Unless waste is visibly soiled, dripping, or caked with blood or body fluids, it is classified as general waste.[82]
6. Waste from plastic suction bottles can be reduced by reusing the containers and lining them with disposable liners[83] (94% agreement).
7. Empty drug ampoules or crystalloid fluid solutions bags are not bio-hazardous. Therefore, they should follow standard glass / plastic recycling protocols[84] (94% agreement).

Impact measures

- National and international benchmarks assert that OR clinical waste should be no more than 15% of the total waste stream, with the best performers driving this down to well below 10%.[85]

Challenges of implementation

- Provide "general waste" bags in the OR until the patient is wheeled in, as a means of reducing clinical waste.[84]
- Increase the number of bins for both clinical and general waste, design local visual aids (signs, posters, images), and train all OR staff.
- Separating waste produced before a patient enters the OR from waste produced during the procedure allows reducing regulated medical waste by 50%.[86]

Drugs recommendations

1. Limit the preparation of drugs to be used "in case of emergency" (100% agreement).
2. Use prefilled syringes when feasible (eg atropine, ephedrine, adrenaline).
   Their use can reduce waste and possibly reduce the risk of critical error during drug preparation, especially when they need to be prepared promptly[87] (100% agreement).
3. Reduce propofol waste by using 20 ml propofol ampoules. Reserve the 50- and 100-ml bottles for TIVA/TCI syringes. Avoid leftovers and remember to discard medication in a designated area, not in the sink (94% agreement).
4. Adjust stock levels to minimise discarding expired items (97% agreement).

Impact measures

- Monitoring and documentation of wasted anaesthetic drugs on daily/weekly/yearly level, and per hour of anaesthesia.

- Monitoring and documentation of discarded anaesthetic supplies due to time expiration on a daily/weekly/yearly level, and per hour of anaesthesia.
- Monitoring and documentation of unused anaesthetic and/or surgical kit items in daily/weekly/yearly level, and per hour of anaesthesia.

Challenges of implementation

- Education of all personnel about the environmental impact of drug and material wastage should be encouraged.
- Redesign of anaesthesia supply carts and surgical kits according to real needs.

Recycling recommendations

1. Staff education in waste management and separation should be provided and encouraged (100% agreement).
2. Separate and recycle uncontaminated paper/cardboard, medical plastic and metal to certified sustainable recycling companies[76] (100% agreement).
3. Be aware of materials with a high recycling potential. Nonwoven polypropylene (PP) wrapping paper or halogen gas aluminium bottles have a high recycling potential[88] (100% agreement).
4. Recycle or appropriately dispose of electronic equipment and batteries to certified sustainable recycling companies[76] (100% agreement).
5. Donate expired or unused open equipment according to local legislations (97% agreement).

Impact measures

- Regular visual and data checks to the recycling bins that are in place.

Challenges of implementation

- Increase the number of bins for both clinical and general waste.
- Continuous education of the staff on general and clinical waste separation.

Behavioural change

Supplemental File 5, http://links.lww.com/EJA/A908 shows a clinical bundle to reduce the carbon footprint of anaesthetic practice in relation with scope three. It can be posted beside designated recycling bins within the OR as a cognitive aid.

Scope 4

There is rising awareness within the anaesthesiology community towards the importance of wellbeing and the risks related to fatigue. Both issues are crucial in anaesthesia and intensive care, where rapid decision making, technical expertise and high levels of concentration are essential for patient safety. Various studies conducted in different European countries identify a significant number of anaesthesiologists feeling emotional or mentally unwell due to work-related stress and fatigue. Night-time work is one of the most common causes of fatigue.[89] There is a growing body of evidence suggesting an association between poorer patient perioperative outcomes and night-time surgery or perioperative care. This association cannot be fully explained by patient or surgical characteristics, where human factors such as fatigue can play a key role.[89,90]

Wellbeing

Sleep deprivation and fatigue can significantly impact on a healthcare professional's performance at work during night shifts. Night shift workers are more likely to make simple mistakes and avoidable errors, due to altered critical thinking, reduced visual-motor coordination and slower reactions to stimuli, leading to increased risks to patient safety.[91–93] A national survey among anaesthesiologists in New Zealand showed that 80% of respondents disclosed having made a medical error due to fatigue.[94] Another recent survey among trainees in anaesthesia from the UK showed that night-time work was the main cause of fatigue and that only 29% of respondents were actively encouraged to rest during their night shift.[95] Around 37% of the trainees and 45% of the consultants surveyed admitted having had an accident or near miss when driving home after their shift.[95,96] An ESAIC cross-sectional survey among nearly 6000 anaesthesiologists, including almost 1000 trainees, showed a worrisome picture about the perception of the impact of perioperative night-time work conditions on patient outcomes and their own quality of life.[89] Most respondents believed that sleep deprivation affects their professional performance (71%), and that their fatigue during night work may increase peri-operative risks for their patients (74%). Furthermore, 81% of the respondents agreed or strongly agreed that night work is an additional risk for patient safety, and 77% stated that their night work affects the quality of their daily life significantly or extremely.[89] Notably, most respondents (90%) had received no training or information on performance improvement methods for night work, and 50% of respondents declared they do not have the possibility to discuss clinical issues or involve other colleagues for a second-opinion. Indeed, data showed that the overall night-time working conditions are far from adequate in terms of rest facilities and food and beverage provided.[89]

Recommendations

- Professional help and second-opinions from colleagues should be readily available during night-time work in anaesthesia and critical care setting (100% agreement).
- The regular use of on-shift and postshift rest facilities should be encouraged by policy-makers and made easily accessible (100% agreement).
- Education (teaching sessions, e-learning or factual resources, tools to assess driving fitness after night work) should be provided for all healthcare workers

during their degree courses and specialty training, before actively working at night in clinics. It should cover all aspects of fatigue and night-time work, including consequences of fatigue on professional performance and personal life, associated risks, sleep hygiene, nutrition, and the legal implications of driving while tired (100% agreement).
- Appropriate food and beverage supplies should be made available by institutions and policy-makers (97% agreement).

Impact measure

- Accidents during work commute.
- Drug/Clinical mistake error rate.
- Questionnaire to get feedback on resting facilities and duration.
- Questionnaire on self-reporting of the impact on personal life and professional performance of night-time work.

Challenge of implementation

- Resting is not accepted within the team.
- Workload does not allow, or it interrupts rest.
- Adequate resting facilities and free food and beverage supply are not available within the hospital.
- No formal education on fatigue and characteristic risks or tips to improve night-time work are provided by institutions.
- Bad judgement and stigma towards requests for professional help during night-time work.

Specific surveys undertaken by anaesthesiologists working in perioperative or intensive care units have shown a 3–25% incidence of suicidal ideation, depending on how it is defined – the lack of a consistent definition remaining a problem in surveys of this nature.[91,97,98] Moreover, in a survey with 7800 respondents, mental health problems were reported in 41% of the cases.[99] European trainees recently reported an average WHO-Five Wellbeing Index of 38.5 out of 100 maximum possible score, demonstrating a significant negative impact on mental health and emotional wellbeing.[95] The same situation applies to consultants, where 91% of UK Consultants reported work-related fatigue, and over half reporting a moderate or significantly negative impact on health, well being and home life.[96]

Recommendation

- Psychological support must be available on request for all healthcare staff working in the perioperative and critical care setting (100% agreement).
- Easy access to crisis care management (psychological care and suicide prevention should be anonymously provided by employers, especially after crises) (100% agreement).
- Post crisis debriefing for all healthcare professionals involved in stressful events should be provided on a regular basis (100% agreement).
- Implement a wellbeing support group to maintain a mentally healthy workforce (100% agreement).

Impact measure

- Suicide rate.
- Sickness absence.
- Anonymous annual staff surveys questioning wellbeing/addictions/sleep disorders.
- Burn out rate.

Challenge of implementation

- Need for psychological help might be seen as a weakness and not communicated among healthcare workers.
- Stigma associated with mental health.

In 2020, 44% of NHS staff reported feeling unwell due to work related stress in the last 12 month, an increase of 40.3% from 2019. Overall, 74% of staff felt they were well supported but only 56% among those whose personal social and family support backgrounds were less than ideal agreed on this statement.[99] On the other hand 62% of consultants in the UK reported not feeling supported by their department to maintain their wellbeing.[96]

Recommendation

- Fatigue should be openly acknowledged as a hazard by managers and policy-makers.
  Wellbeing should be prioritised in order to enable a supportive working environment and optimise workforce efficiency and patient safety (100% agreement).
- The implementation of a fatigue risk management system (FRMS)[100] can contribute to adaptation of the working arrangements (e.g. stopping on-calls or implementing flexible/part-time arrangements) (97% agreement).
- Night-time work should be openly acknowledged as different from day-time work due to specific risks and the impact on personal and professional life (100% agreement).
- Consider postponing surgery to day-time, when feasible (ie not life- or limb-saving), to diminish the burden to on-call staff and enhance patient safety[101] (100% agreement).
- Departments should ensure that their professional rotas are EWTD (European Working Time Directive) compliant, or to national law (for countries outside the European Union) (97% agreement).

Impact measure

- Resignation rate, sickness absence, staff survey/feedback, job vacancies, FRMS, burn-out rate.

Challenge of implementation

- Lack of time and knowledge about inclusive leadership strategies.
- Lack of finance and knowledge about implementing a risk-based framework.
- Changing organisational culture to encourage reports of fatigue or fatigue related incidents/errors.

A review of 17 studies dealing with shift work and cardiovascular disease demonstrated that shift workers had a 40% increased risk of cardiovascular disease compared with day workers.[102] Studies suggest a relationship between years worked in shifts with BMI and Waist-Hip Ratio for both males and females due to changed dietary or metabolic effects.[103]

Recommendatio

- Education, and facilities to enable healthy nutrition during shift work should be provided[104] (100% agreement).
- Healthy food and beverage should be made available (94% agreement).

Impact measure

- Disability, sickness absence, cardiovascular diseases among anaesthesiologists / intensivists

Challenge of implementation

- Accessibility and cost efficiency of fresh food and beverages.
- No access to healthy food and beverages during shift work.

Scope 4—transport

Introduction

In Europe, rapid growth of road transport has affected our health and environment through road traffic accidents, air pollution, congestion and noise. Transportation has contributed to sedentary lifestyles and increase emissions of greenhouse gases.

The World Health Organisation has identified air pollution and noise from transport as a significant environmental cause of ill health. Noise exposure can lead to sleep disturbance, poor mental health and wellbeing, impaired cognitive function in children, and negative effects on the cardiovascular and metabolic system.[105] Moreover, sedentary lifestyle can be improved with physical activity which contributes to lower obesity and diabetes adult rates.[106]

The healthcare industry procurement, and both patient and employee commutes are highly dependent on fossil fuel based transportation.[107–109] By adopting more environmentally friendly transport plans, healthcare systems can reduce their burden on the environment and patients' health.[110] Active commuting has a significant positive effect on mental health. It is associated with lower levels of depression, anxiety, and stress. Actively promoting healthier travel options has been shown to reduce absenteeism and increase job satisfaction.[111]

Reducing the carbon footprint of patient transportation and healthcare professionals commute to work

Recommendation

- Replace on-site hospital perioperative patient assessment with telemedicine in preoperative assessment, pain clinic, and prehabilitation.
  Keep on-site assessment for high-risk patients (97% agreement).
- Support teleworking for professionals and design digital care pathways (100% agreement).
- Consolidate multiple appointments into fewer patient journeys to the hospital (97% agreement).
- Use electric vehicles for patient and employee transfers (97% agreement).
- Promote walking, and cycling to reach hospital centres by increasing the number of bicycle lanes and vehicle free pathways. Promote public transportation for longer distances (100% agreement).

Impact measure

- Number of patient journeys or travel distance reduced in a year.
- Measuring the carbon emissions savings of patients' journeys to the clinic in the traditional care model, versus the carbon emissions of the telemedicine clinic.
- Measure staff commute behaviours.

Challenges of implementation

- Patient's expectation to meet a healthcare professional face to face.
- Patients may lack digital competence, or resources to access virtual software.
- Clinical signs may be missed which may compromise perioperative care.
- Integration of technological innovation in perioperative care and pain clinics.
- Pedestrian and cycle traffic infrastructure inadequate, unsafe, or nonexistent
- Insufficient and inconvenient public transport
- Insufficient charging points and cycle storage facilities at the workplace
- Budgets to procure low emission vehicles
- Longer commute at the expense of time with family

Reduce carbon footprint of scientific conferences and implementation of sustainable event management

The carbon footprint of the whole global events industry is responsible for more than 10% of the global CO_2 emissions.[112]

The environmental impact of an international conference is dominated by the travel activity of the participants. There has been an increasing demand for mitigation of the environmental impacts of scientific conferences.

By switching from in person conference to pure virtual mode reduces the carbon footprint by 94%. Spatially optimal hubs for the hybrid conferences have the potential to slash carbon footprint and energy use by 60–70% while maintaining <50% of virtual participation.[112,113]

Recommendation

- Consider the transportation profile of the conference location. Optimise the geographical location to reduce the travel distance for the target participants. Conference venues should be easily accessible by public transport (100% agreement).
- Promote virtual conferences and meetings, which are less carbon intensive (100% agreement).
- Consider hybrid meetings with a physical hub located near groups of delegates to reduce their travel carbon footprint while maximising the advantages of in person and digital conferences[10] (100% agreement).
- Introduce a carbon footprint declaration when organising a conference to increase awareness among participants (100% agreement).
- Participants should consider their potential travel carbon footprint. Promote green transport methods and minimise the need for car travel (100% agreement).
- Aim to organise and /or participate in carbon neutral conferences (100% agreement).

Impact measure

- Cumulative travel carbon footprint of participants at the conference.
- Calculating the reduction of the carbon footprint by shifting to hybrid conference formats.
- Life cycle analysis of an organised conference.

Challenges to implementation

- Loss of interpersonal exchange.
- Digital meeting fatigue.
- Meetings in different time zones.
- Inadequate technology and telecommunication services.

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