

## **How Can We Reduce the Environmental Impact of Obstetric Anaesthesia?**

### **Introduction**

Environmental degradation poses a serious threat to our health, wellbeing and survival.<sup>1-3</sup> The past two decades, especially, have seen an increased interest in human-induced environmental impacts, with increasing recognition that human activities result in the release of a large quantity and variety of hazardous chemical compounds, many of which negatively impact upon the environment.<sup>4-5</sup>

### **The Rise of Environmental Awareness**

Environmental protection is the practice of protecting the natural environment by individuals, organizations and governments.<sup>6</sup> Its objectives are to conserve natural resources and the existing natural environment and, where possible, to repair damage and reverse trends.<sup>[6]</sup>

Early interest in environmental protection was a feature of the Romantic movement of the early 19th century.<sup>7</sup> In the 20th century, due to the pressures of overconsumption, population growth and technology, the perceived need for environmental protection has continued to grow in popularity and recognition. The National Environmental Policy Act (NEPA),<sup>8</sup> a United States environmental law that promotes enhancement of the environment, grew out of the increased public appreciation and concern for the environment that developed during the 1960s. During this time, environmental interest group efforts and the growing public awareness resulting from Silent Spring led to support for the Act and subsequent legislation in the US.<sup>9,10</sup>

In the UK, similar measures were also introduced to allay concerns arising from increasing industrialization, urban and suburban growth, and pollution. The Control of Pollution Act, established in 1974,<sup>11</sup> was passed to cover a number of environmental issues such as air, noise, water and atmospheric pollution. Introduced in 1990, the Environment Protection Act, has since re-enacted these provisions in the UK, targeting waste management and emissions.<sup>12</sup>

If anything, since the 20th century, these environmental issues have continued to become more extensive, more urgent and have received greater publicity. Numerous eloquent and impassioned environmental advocates, with the capacity to reach a broad audience on issues such as climate change have also risen in prominence, with their messages shaping views, policy and legislation alike, in order to secure a stable, prosperous and equitable future on our endangered planet (Figure 1).<sup>13,14</sup>

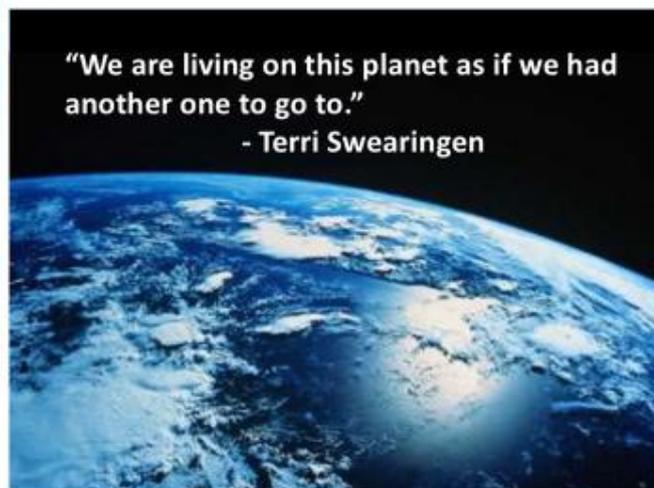


Figure 1. Statements of Environmental Advocates.<sup>13,14</sup>

## Environmental Protection: A Role for the Anaesthetist?

With climate change being cited as ‘potentially the biggest global health threat of the 21st century’,<sup>2</sup> the medical profession is facing policy and healthcare pressures which have forced engagement with environmental issues.<sup>15,16</sup> Healthcare systems have since been encouraged to develop strategies to mitigate (avoid the unmanageable) and adapt (manage the unavoidable) to environmental pressures.<sup>5</sup>

In 2009 the AAGBI hosted a seminar on ‘The Anaesthetist and the Environment’ and in 2010 began to consider the environmental footprint of anaesthesia.<sup>17</sup> Perhaps the most important public action was to produce an Environmental Policy Statement in 2012, stating that *‘the AAGBI recognises that our actions have an impact on the environment around us and regards sustainability and climate change as a key strategic issue’*.<sup>18</sup> This statement has since been endorsed by both the RCoA and CAI, who have since committed to the promotion of sustainability through the Joint Environmental Policy Statement with the Association of Anaesthetists (AoA) as outlined below (Figure 2).<sup>19</sup>



### Joint Environmental Policy Statement (July 2017)

The Association of Anaesthetists (the Association), The Royal College of Anaesthetists (RCoA) and the College of Anaesthesiologists of Ireland (CAI), recognise that the professional actions of anaesthetists have an environmental impact and that this, in turn, may affect people's health and wellbeing both now and in the future. For this reason, we are committed to promoting environmental sustainability across our own activities as well as encouraging and supporting action by our members and fellows. This includes, but is not limited to, mitigating the adverse effects of climate change, prudent use of natural resources and minimising waste.

Figure 2. Joint Environmental Policy Statement.<sup>19</sup>

## Making a Green Start: A Role for all Healthcare Professionals

Healthcare professionals are powerful catalysts for facilitating change within society, and ten practical steps were endorsed in 2008 for all doctors to combat climate change (Figure 3).<sup>20</sup>

- 1 Inform ourselves about the basic science of climate change, the health benefits of taking action, and the urgency of doing so.
- 2 Advise our patients. Better diet and more walking and cycling will improve their health and reduce their carbon emissions.
- 3 Use less energy ourselves (and reduce costs) by more insulation in the roof, walls, and floors; turning off appliances and lights; and, where possible, reducing use of goods and services.
- 4 Drive the car less; fly less; walk or cycle more; use public transport; drive an efficient car; share cars; hold meetings by teleconference, videoconference, or webcasting; attend fewer international conferences.
- 5 Influence food menus wherever we go—ask for local food, less meat, and less processed food; a low carbon diet is a healthy diet. Drink tap water.
- 6 Advocate locally, especially in primary care, to maximise home insulation and uptake of relevant grants.
- 7 Advocate for personal carbon entitlements within an equitable, fair shares global framework, such as Contraction and Convergence.
- 8 Advocate to stabilise population—by promoting literacy and promoting women's access to birth control, through the International Planned Parenthood Federation ([www.ippf.org](http://www.ippf.org)) or Marie Stopes International ([www.mariestopes.org.uk](http://www.mariestopes.org.uk)).
- 9 Be a champion: put climate change on the agenda of all meetings—clinical teams, committees, professional networks. Doctors can tip opinion with chairs and chief executives.
- 10 Gear up your own influence and that of all health professionals by joining the Climate and Health Council ([www.climateandhealth.org](http://www.climateandhealth.org)) or the Health and Sustainability Network ([www.healthandsustainability.net](http://www.healthandsustainability.net)), or both.

Figure 3. Ten practical steps for doctors to fight climate change.<sup>20</sup>

Evidently, there are numerous means through which all healthcare providers can mitigate and adapt to climate change and as the remainder of this paper reveals, the potential for the obstetric anaesthetist is no less significant.

## What are the Environmental Impacts of Obstetric Anaesthesia and What Can We Do?

### Inhalational Agents

#### *Environmental Impact*

A marked rise in atmospheric greenhouse gas (GHG) concentrations has occurred since the industrial era of the 1800s,<sup>21</sup> with the Intergovernmental Panel on Climate Change concluding that 'most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas

concentrations'.<sup>4,22</sup> Numerous problems have been associated with such temperature rises, from increased disease burden from heat waves and drought to loss of ecosystems including habitats and species.<sup>2</sup>

The GHGs include carbon dioxide, methane, nitrous oxide, water and all of the halogenated anaesthetic agents.<sup>23</sup> Since multiple GHGs exist, it is their combined effect that is often evaluated, using carbon dioxide equivalents (CDE), or their 'carbon footprint' (CO<sub>2</sub>e, kg). It has been estimated that the annual global climatic impact of anaesthetic agents released into the atmosphere is 4.4 million tonnes of CO<sub>2</sub>e.<sup>24</sup> By comparison, the annual global emissions of GHGs are estimated as 49 gigatonnes CO<sub>2</sub>e, of which 24% originate from agriculture, 14% from the transport sector and 2.1% originate from healthcare,<sup>25,26</sup> of which anaesthetic gases contribute around 5% of the total carbon emissions of the acute healthcare facilities.<sup>27</sup> The carbon dioxide footprint of each anaesthetic gas can be calculated by multiplying the total mass released into the atmosphere by the global warming potential (GWP) over a specified time period. The GWP is a relative measure of how much heat a given gas traps in the atmosphere compared with a similar mass of CO<sub>2</sub>. The GWP is often expressed over a 20-year time horizon (GWP<sub>20</sub>), with values for desflurane, isoflurane, sevoflurane and nitrous oxide being 6810, 1800, 440 and 289 respectively.<sup>21,28-30</sup>

In addition, nitrous oxide has also been described as 'the single most important ozone-depleting emission throughout the 21st century'.<sup>31,32</sup> The global Montreal Protocol was amended in 2016 to control hydrofluorocarbons use, but relatively little consideration was given to anaesthetic gases, which were considered to be medically essential and used in relatively small quantities.<sup>33</sup> Whilst medical emissions of atmospheric nitrous oxide are by no means the most significant (less than 4% of all nitrous oxide emissions), 90% of the NHS carbon footprint due to anaesthetic gas use is due to nitrous oxide, most of which is used in the delivery suite.<sup>23</sup>

### *What Can We Do?*

As anaesthetic vapours are minimally metabolized they are exhaled predominantly unchanged. All vapour added to the circuit ultimately ends up in the environment and thus the Control of Substances Hazardous to Health regulations may act to reduce theatre pollution but have little effect on the environmental footprint.<sup>23</sup> The environmental impact of inhaled anaesthetic agents, therefore, depends on the total annual consumption, which is determined by the fresh gas flow rate, the use of nitrous oxide and the potency of the agent being delivered in conjunction with the GWP.<sup>34</sup>

With greater understanding of the relative environmental impacts of each agent, the American Society of Anesthesiologists has recently released a comprehensive document proposing actions that may favourably impact upon the environment.<sup>34</sup> Suggestions to reduce carbon footprints included low-flow anaesthesia, changing to a practice of turning off FGF rather than the vaporiser (which will limit agent wastage during such procedures as moving or positioning the patient, or endotracheal intubation following induction of anaesthesia), the use of regional anaesthesia and total intravenous anaesthesia where possible, selective use of nitrous oxide and avoidance of desflurane.<sup>35</sup> Indeed, such changes have already been shown to substantially reduce an institution's carbon footprint, as demonstrated by the University of British Columbia (UBC), where a 66% reduction in GHG emissions was observed (Figure 4).<sup>28,36</sup>

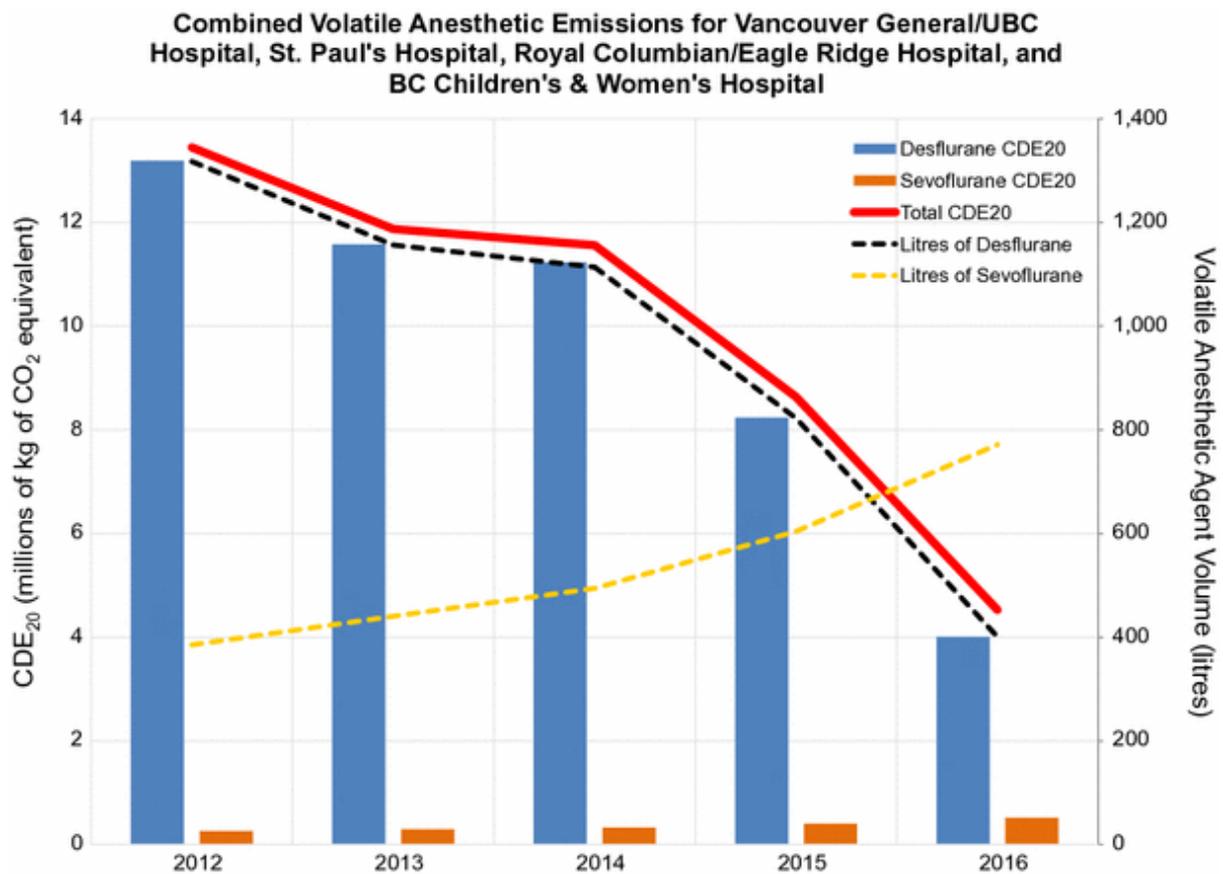


Figure 4. UBC use of desflurane and sevoflurane and environmental impact (2012-2016).<sup>28</sup>

The use of charcoal and reflection filters offer further options for anaesthetic agent conservation, potentially reducing agent consumption by 40-75%.<sup>37-40</sup> Once vapourised, however, the only long-term effective means of reducing agent release into the atmosphere is to capture and recycle or to render them chemically inert. In Canada, a commercially available silica zeolite canister has been shown to completely remove isoflurane from exhaled gases, which is then returned to the company for extraction and reprocessing.<sup>41</sup> Whilst none of the previously described techniques can be applied to nitrous oxide, mobile units are commercially available to catalytically convert it to oxygen and nitrogen (Excidio; Linde Group, Sweden). This type of technology can result in a six-to 17-fold reduction in CO<sub>2</sub>e and can also collect halogenated anaesthetic agents.<sup>42,43</sup> Widespread use of such technology could revolutionise anaesthetic agent procurement and emissions, which given that the development

of effective, safe and environmentally benign novel volatiles agents are not forthcoming, represent a promising pathway to pursue.<sup>44,45</sup>

Of course, utilisation of anaesthetic vapours frequently occurs in the Delivery suite, beyond the operating theatre. Entonox is used by up to 60% of labouring mothers with a number of strategies also available to eliminate or reduce nitrous oxide use.<sup>46,47</sup> Alternative analgesic regimes include early, effective epidural analgesia, with frequent observation and early re-siting, re-positioning or topping-up, which may not only reduce, but completely eliminate the need to use nitrous oxide. Similarly, use of remifentanyl patient controlled analgesia and the aforementioned technology using collection and catalytic conversion of nitrous oxide may have beneficial effects.

## Intravenous Agents

### *Environmental Impact*

The use of total intravenous anaesthesia may eliminate the GHG effect of volatile anaesthetic agents; however, there is an environmental cost as a result of their manufacture, transport, disposal and electricity consumption for their delivery. For instance, the carbon footprint of propofol use primarily stems from the energy required to operate the syringe pump.<sup>29</sup> In addition, when calculating the impact of intravenous morphine preparations, the final stages (particularly sterilisation and packaging) contributed to almost 90% of morphine's carbon footprint.<sup>48</sup> Incidentally, the same is not true of halogenated anaesthetic agents, where the downstream CO<sub>2</sub>e of waste emissions are significantly higher than the manufacture, and procurement footprint.<sup>29</sup>

Preparation for adverse outcomes is a basic tenet of anaesthesia, perhaps even more so in obstetric anaesthesia. However, automatically preparing emergency drugs for every case may

lead to a stunning amount of waste,<sup>34</sup> a significant carbon footprint,<sup>49,50</sup> and pollution of water supplies.<sup>34,51</sup>

### *What Can We Do?*

Given the profound negative environmental impacts of anaesthetic vapour the logical response is to simply switch to Total Intravenous Anesthesia (TIVA).<sup>34</sup> However, TIVA models were never tested on or designed for parturients, where drug pharmacokinetics are significantly altered. In addition, in emergency situations where general anaesthesia is required there is little time to prepare intravenous medications and accurately program syringe drivers, compounded by the fact that TIVA syringe drivers were not designed to facilitate a rapid sequence induction. Furthermore, use of remifentanyl at induction also has the potential to cause neonatal respiratory depression and higher APGAR scores at delivery.<sup>52</sup>

Altering prescribing practices may have significant carbon impacts though. There are numerous effective ways to reduce waste for these drugs without diminishing patient safety.

One approach may entail prescribing and preparing appropriate medications only for immediate clinical need. Barcoded, prefilled syringes or pre-packed kits may also reduce drug wastage and potentially drug errors too. In addition, use of appropriately sized vials (e.g.: smaller than standard 5 mg diamorphine vials) and replacing parenteral drugs, such as paracetamol and non-steroidal anti-inflammatory drugs, with enteral drugs may also have positive environmental effects.<sup>34</sup>

Alongside pharmaceutical waste management, drug selection may also have environmental implications. In 2003 the Stockholm County Council started an environmental risk-classification database of pharmaceuticals with the goal of diminishing pharmaceutical residue in the water, air and ground.<sup>53</sup> While not all commonly used anaesthesia drugs are included or fully evaluated, the initial findings suggested that propofol may not be an

environmentally sound choice since it has the highest Persistence, Bioaccumulation and Toxicity index.<sup>34</sup>

Resources, Equipment and Consumables

### *Environmental Impact*

Operating theatres use large amounts of energy and consumables with around 60% of the carbon footprint of a hospital likely to result from procurement of materials and equipment.<sup>54,55</sup> Factors guiding the purchasing of anaesthesia equipment have traditionally been: safety, efficacy, cost, and infection control. A relatively novel approach to medical purchasing is also to consider environmental sustainability.<sup>34,55,56</sup> Yet, in anaesthesia, there remains great pressure to avoid reuse of devices to optimise infection control.<sup>57</sup>

Numerous life cycle assessments, analysing the environmental footprints arising from the extraction, manufacture, transport, use, recycling/waste disposal/reuse of equipment or processes have been conducted for multiple anaesthesia items, comparing reusable versus single use variants. A number of studies comparing reusable versus single-use equipment: gowns,<sup>58</sup> drapes,<sup>59,60</sup> and laryngeal mask airways<sup>61</sup> have shown that re-using equipment can significantly reduce carbon footprints.

### *What Can We Do?*

Development of greater understanding regarding the risks of infection and methods of decontamination may better inform future decisions. Given that converting to reusable rather than single-use equipment in a five-theatre medical hospital was estimated to result in 84% reduction in CO<sub>2</sub> emissions and an annual saving of around £18,000,<sup>62,63</sup> without negating infection control,<sup>64</sup> the potential benefit of intensified resource re-utilisation is vast.

Beyond equipment re-use, high-priority resources to conserve include electricity, gas, oil, water and paper. Simple changes in the anaesthesia department may include turning off

electronic equipment such as scavenging systems, air conditioning or forced warm air machines when not in use, using alcohol-based scrubs or intermittent water flow devices for hand asepsis to reduce water consumption, redesigning sterile procedure kits to reduce wastage, and installing rechargeable batteries in portable equipment.<sup>26,34,65-67</sup> Incorporating sustainability into procurement planning is becoming increasingly essential and suggestions to achieve this have already been outlined (Table 1).<sup>5</sup>

| Area                                                                | Examples and resources                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Evidence from suppliers of environmental policies or accreditations | Accreditation standards include: <ul style="list-style-type: none"> <li>• ISO 14001 (International Organization for Standardization: Environmental Management)</li> <li>• EMAS (European Union Eco-management and Audit Scheme)</li> <li>• The Carbon Trust</li> <li>• Investors in the Environment (UK only)</li> <li>• Green Guide for Healthcare (self-certifying)</li> </ul> |
| Environmental legislation and compliance, management and impacts    | Environmental management schemes; environmental policies; waste certificates; duty-of-care visits; carbon life-cycle impacts; supporting local businesses; zero-to-landfill policies                                                                                                                                                                                             |
| Energy                                                              | Sourcing renewable energy; divesting from fossil fuels                                                                                                                                                                                                                                                                                                                           |
| Packaging                                                           | Requesting recyclable, reusable, biodegradable and minimal packaging                                                                                                                                                                                                                                                                                                             |
| Transport costs                                                     | Reducing number and distance of journeys; consolidating deliveries; teleconferencing                                                                                                                                                                                                                                                                                             |
| Product choice                                                      | Avoidance of environmentally toxic products; energy efficient equipment; healthier and sustainable foods                                                                                                                                                                                                                                                                         |
| Stock control                                                       | Stock so that supply is sufficient but items do not go out-of-date; reuse or recycle before reordering                                                                                                                                                                                                                                                                           |
| Ethical procurement                                                 | Knowledge of supply chain to protect labour standards; source Fair Trade products; follow ethical procurement guidelines ( <a href="#">British Medical Association, 2017</a> )                                                                                                                                                                                                   |
| Water management                                                    | Employ water-saving devices; avoid bottled water; 'grey' water facilities; drought-resistant planting                                                                                                                                                                                                                                                                            |

Table 1. Example of a sustainable procurement policy.<sup>5</sup>

## Waste Management

### *Environmental Impact*

Waste can be defined as a substance that is discarded, rejected, unwanted, surplus, abandoned, emitted or deposited in the environment so as to cause an alteration in that environment.<sup>68-70</sup> Reducing waste is a key component in improving environmental sustainability in anaesthetic practice and mitigating climate change,<sup>63,71</sup> with national waste

policies guiding efficient resource use, reducing the environmental impact of waste management and providing strategies to reducing waste generation.<sup>72</sup> Operating rooms generate 20-30% of total hospital waste and of this, 20-25% comes from anaesthetic services specifically.<sup>71,73</sup> Unfortunately, waste production is increasing and our current efforts are not keeping up.<sup>63,70,72,74,75</sup>

*What Can We Do?*

A legal duty of care was placed on business and public bodies to manage waste, with systematic application of the waste hierarchy principles into the medical environment, with adoption of the five Rs: reducing, reusing, recycling, rethinking and researching (Figure 5).<sup>5,65,76</sup>

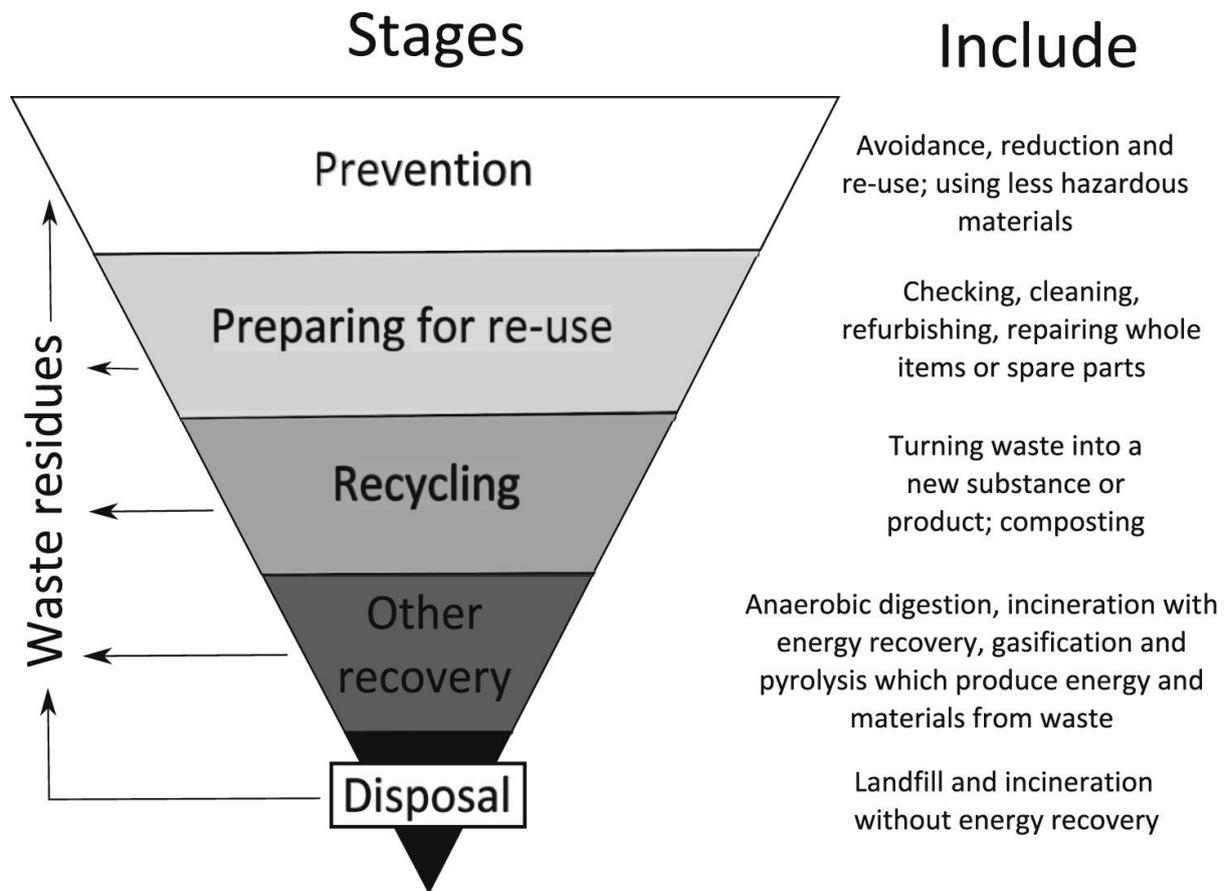


Figure 5. The Waste Hierarchy.<sup>5,76</sup>

Waste reduction is a vital first step and may involve ordering less stock, ensuring stores remain within expiry dates and are not discarded.<sup>50,77</sup> Preparing, using and re-using consumables only when required also reduces the amount of waste produced, in addition to reducing wastefulness.<sup>34,73,77,78</sup> This can apply to both drugs, equipment and energy consumption (considered earlier).

Anaesthetists use large amounts of plastics, which may create high volume landfill and may leech hazardous chemicals when disposed of or incinerated.<sup>17,79</sup> Recently, the UK's Environmental Agency has granted a permit for contaminated medical-grade PVC to be recycled into tree ties, which may reduce production energy consumption by 85%.<sup>80</sup> The use of recycled paper also diverts paper waste from landfill, which is a significant GHG contributor.<sup>77</sup> Recycling has many benefits both economically and in mitigating the effects of climate change, though when compared to reducing waste production and reusing items, it is less energy efficient.<sup>75,77</sup> Despite this, given that 40 – 58% of medical anaesthetic waste may be recycled,<sup>81,82</sup> recycling remains a measure not to be ignored.

Rethinking how clinicians produce waste and ways in which waste minimisation can occur will help to make changes that are sustainable in the long term. Encouraging audit and research in the area of waste management will continue to assist in improving and rethinking methods of waste reduction and environmental sustainability.<sup>35,69,77,82-84</sup>

Away from the clinical environment, other methods that can be considered in waste management include having composting facilities available in hospital lunch rooms<sup>77</sup> and eliminating the provision of single-use kitchenware (cups, crockery, cutlery) in favour of staff using their own reusable items.<sup>34</sup>

Rational use of Diagnostic Tests and Prescribing

### *Environmental Impact*

Clinical inefficiencies in the provision of health care, such as interventions that do not meet patient expectations or provide the desired outcomes include unnecessary activity by both patient and staff movement, excessive waiting times, and the over-ordering of investigations and interventions.<sup>85-87</sup> The environmental impact of diagnostic tests and prescriptions is primarily generated from the production of medical items and medications, transport and procurement, and waste disposal.<sup>48,63</sup>

### *What Can We Do?*

The UK's Academy of Medical Royal Colleges published a report that demonstrated how appropriate use and resources can not only achieve better value in care but also reduce the carbon footprint of a health service.<sup>85,87,88</sup> Reducing the number of unnecessary diagnostic tests and prescription of drugs can, therefore, significantly reduce the overall environmental impact.

### Awareness and Engagement

#### *Environmental Impact*

Healthcare activities contribute 3% of the UK's national carbon emissions, but it has committed to an 80% reduction carbon emissions by 2050.<sup>74</sup> There are various global medical healthcare initiatives which are driving sustainability via leadership, policy, research and education,<sup>5</sup> with the Association of Anaesthetists producing a newsletter which gives an engaging summary of activities, including research awards, 'greening' the headquarters and promoting sustainable conferencing with no conference bags, careful choice of location and venues, teleconferencing and meat-free days.<sup>89</sup>

### *What Can We Do?*

Currently, there is little cohesive focus within the profession to reduce the environmental footprint of anaesthesia.<sup>5</sup> Raising awareness is a crucial step, with ongoing education and encouragement necessary to stimulate cultural change.<sup>83</sup>

## **Conclusion**

Environmental degradation is increasingly being recognised as a major health threat and although the exact global impact of obstetric anaesthesia remains uncertain, given that approximately 200 million anaesthetics are delivered annually worldwide, it is not insignificant. The sustainability movement in medicine has made great progress over the past decade, with various global medical healthcare initiatives driving a change of practice. Given that anaesthesia prides itself on being at the forefront of patient safety and the devastating effects of climate change, obstetric anaesthetists, alongside all other healthcare professionals, can no longer ignore the impact that our actions have on the environment. Instead, we must embrace the opportunity and our responsibility to challenge and mitigate the negative environmental impacts of our profession.

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