Australian and New Zealand College of Anaesthetists (ANZCA)

Faculty of Pain Medicine

Statement on Environmental Sustainability in Anaesthesia and Pain Medicine Practice

Background Paper

INTRODUCTION

The health of the environment is a public health issue. The Australian Medical Council's Code of Conduct for Doctors states that "good medical practice involves using your expertise and influence to protect and advance the health and wellbeing of individual patients, communities and populations"[1]. Anaesthetists and pain physicians have a role to play in mitigating climate change and environmental degradation as daily work practices have the potential to influence greenhouse gas emissions and environmental pollution. On an average working day, an individual anaesthetist can contribute the CO_2 equivalent of more than 1,000km of car driving by administering nitrous oxide or desflurane [2,3,] Every day, United States operating room staff deposits into landfill more than 1,000 tons of rubbish, of which anaesthesia practice is likely to contribute 1/4 of the total, and of which up to 60% may be recyclable[4-7]. Current data demonstrates that 7% of Australia's total carbon footprint can be attributed to the healthcare industry; 44% of emissions were from hospitals[8].

JUSTIFICATION

Anthropogenic greenhouse gas emissions contribute to climate change [9]. The global mean surface temperature has risen by approximately 0.85°C in the last 130 years, with each of the last 3 decades being successively warmer than any preceding decade since 1850. It is projected to exceed 2°C by the end of the 21st century without significant greenhouse gas mitigation [10].

The health implications associated with warming of the climate system are, and are predicted to be, widespread and devastating [11]. Climate change affects the social and environmental determinants of health – clean air, safe water, sufficient food, freedom from disease and secure shelter [12]. It also amplifies extreme weather events such as heatwaves, droughts, floods and storms. The World Health Organisation (WHO) estimates that between 2030 and 2050, climate change will lead to approximately 250,000 additional deaths per year globally [12]. Whilst Australia and New Zealand may at present be relatively immune to some of the global climate change health threats such as malnutrition and malaria, there are aspects that have already directly affected us. For example, Australia's average temperatures have increased over the last 50 years leading to hotter, longer and more frequent heatwaves, which are predicted to become even more extreme and prolonged [13,14]. Heatwaves have led to more deaths in Australia over the past 100 years than any other natural event [15]. New Zealand will also be affected by climate change with higher temperatures, shifting rainfall patterns and increased flooding and erosion in many coastal areas [16].

Climate change is widely considered 'the biggest health threat of the 21st century,[11] with the 8th United Nations' Secretary General Ban Ki-moon describing it as the "true existential threat to our planet… as it threatens all our goals for development and social progress". Health professionals have a vital role to play in minimising and tackling the health impacts of climate change [17]. Furthermore, policies instigated to address and mitigate climate change could be "the greatest global health opportunity of the 21st century" [18] because climate change mitigation measures can lead to health co-benefits such as improved air quality, more physically active modes of transport and healthier dietary choices.

Environmental degradation and pollution are also major threats to our health. In 2012, the WHO estimated that exposures to polluted soil, water, and air contributed to an estimated 8.9 million deaths worldwide [19], with ambient air pollution alone causing 3.7 million deaths [20]. In Australia, over 3000 deaths per year are presently attributed to air pollution (double our national road toll) [21]. Exposure to air pollution, toxic chemicals, and pesticides are the main forms of pollution today causing disease in high-income countries. WHO has published an Atlas on children's health and the environment, noting that "26% of the deaths of 5.9 million children who died before reaching their fifth birthday could have been prevented through addressing environmental risks" [22,23].There is also increasing evidence that individuals can pass the risk of environmentally related non-communicable diseases to their children, for example via epigenetic mechanisms [22].

REVIEW OF ISSUES

Anaesthetic agents

Currently available anaesthetic agents have environmental impact related to their physicochemical properties and waste associated with their manufacture, use and disposal. Halogenated organic compounds are responsible for a warming effect of approximately 10-15% of the total radiative forcing of climate despite being present in the atmosphere at a concentration around 100,000 times lower than carbon dioxide [24]. Inhalational anaesthetic agents are increasing in atmospheric concentrations, with sevoflurane and desflurane (hydroflurocarbons), isoflurane (chloroflurocarbon) and nitrous oxide all having some degree of action as a greenhouse gas.

In addition, other elements of the life cycle of anaesthetic agents have a significant broader role in sustainable practice. A background understanding of sustainability issues related to agent choice provides the anaesthetist with obvious opportunities to reduce their impact on the environment. While the direct contribution of anaesthetic agents to issues such as climate change may be small compared to CO_2 released by fossil fuel combustion, it is a contribution over which anaesthetists exercise unique control.

CONCEPTS RELEVANT TO MEASURING ENVIRONMENTAL IMPACTS OF ANAESTHETIC AGENTS

There are a few broad concepts that provide useful background when considering anaesthetic agents and their environmental impact. For volatile agents, concepts related to effects on radiation and what is meant by the term "greenhouse gas" are relevant. An understanding of the impact of nitrous oxide requires a consideration of potential impacts on the ozone layer. For these agents and intravenous anaesthetic agents such as propofol, life cycle assessment (LCA) is a particularly relevant methodology to grasp. LCA is expanded upon further in this document.

CONCEPTS OF RADIATION AND GREENHOUSE GASES

The key feature of gas agents that lends them potential as greenhouse agents is their behaviour as absorbers over the infrared spectrum. Each gaseous agent will absorb infrared radiation over a unique range of wavelengths and this can be assessed by the integrated absorption cross-section. This is a measure of how efficiently the gas in question may affect the balance of radiation entering and leaving the earth's atmosphere.

Where a particular substance has the effect of pushing the balance between incoming and outgoing radiation energy to favour warming, this is referred to as positive radiative forcing. By combining the known lifetime of an inhaled anaesthetic in the atmosphere and radiative forcing over that time, it is possible to calculate the Global Warming Potential (GWP). GWP is therefore a measure of how much a mass of greenhouse gas contributes to global warming in a specified time period [3]. For anaesthetic agents this is often quoted as GWP_{20} and therefore calculated over a 20-year timespan (due to their relatively short atmospheric half-lives), though for nitrous oxide the longer timeframe of GWP_{100} is appropriate.

OZONE LAYER EFFECTS

The potential for compounds to be associated with ozone depletion is measured by the ozone depletion potential (ODP) of the agent in question. Nitrous oxide and halogenated agents that contain chlorine such as isoflurane can potentially be associated with catalytic destruction of ozone in the atmosphere [24]. While halothane would also fall into this group it is now rarely used. Atmospheric oxidation of desflurane and sevoflurane seem not to result in ozone depletion in recent experimental studies. Isoflurane has a relatively short atmospheric lifetime therefore damage is minimal.

VOLATILE ANAESTHETIC AGENTS

Halogenated agents utilised in anaesthesia practice all absorb infrared radiation that would otherwise leave the Earth's lower atmosphere. It is these absorption characteristics that mean they are associated with a greenhouse gas effect [24]. Isoflurane has additional ozone-depleting effects due to interactions with the chlorine groupings within the molecule. This effect is somewhat offset by the short life-span of isoflurane once in the atmosphere.

Accounting for the greenhouse impact of anaesthetic agents requires a consideration of both the time for which the relevant agents remain in the atmosphere and how efficient the agent is in absorbing radiation in the infrared spectrum (refer to Table 1). Nitrous oxide has an atmospheric lifetime of nearly 120 years, whereas isoflurane has an atmospheric lifetime of 3.2 years, desflurane 14 years and sevoflurane 11.1 years. This does not remove the potential for agents that exist in the environment for a relatively short period of time to be destructive to the ozone layer.

Table 1: Summary of radiative properties, atmospheric lifetimes and global warming potentials for commonly used agents

Compound	Atmospheric Lifetime (years)	Radiative Efficiency ($W.m^{-2}.ppb^{-1}$)	GWP – 20 years	GWP – 100 years
Nitrous Oxide	114	0.00303	289	298
Isoflurane	3.2	0.453	1800	510
Desflurane	14	0.469	6810	2540
Sevoflurane	1.1	0.351	440	130

Adapted from Andersen MPS, Nielsen OJ, Wallington TJ et al. [24]

A further consideration with respect to volatile anaesthetics is the amount of the agent required for clinical use (refer to Table 2). This can be calculated by multiplying the quantity of an agent used over a given period by the GWP_{20} for that agent to produce the Carbon Dioxide Equivalent over 20 years (CDE_{20}) [3]. Such calculations provide a demonstration of the significant differences between volatile agents. By comparison to sevoflurane at 1 MAC with fresh gas flow (FGF) of 2 L/min, isoflurane at 1 MAC has an approximately equivalent global warming impact only if FGF is maintained at 1 L/min[3]. For desflurane the comparison is even more stark. At 1.0 and 0.5 mL/min the CDE_{20} of desflurane is 13.4 and 6.7 times higher than for sevoflurane respectively.

Table 2: Comparison of Global Warming Impact of Inhalational Agents at Varied Flow Rates

FGF (L/min)	Grams/hour	CDE_{20} (kg/hr)	CDE_{100} (kg/hr)	Ratio CDE	
				20 yr	100 yr
2% sevoflurane					
2	20.0	8.8	2.6	1	1
1.2% isoflurane					
0.5	2.8	5	1.4	0.6	0.54
1	5.5	10	2.8	1.1	1.1
2	11.1	20	5.6	2.3	2.2
6% desflurane					
0.5	12.6	86	32	9.8	12.3
1	25.2	172	64	19.5	24.6
2	50.4	343	128	39	49.2

Figures derived from Andersen MPS, Nielsen OJ, Wallington TJ et al. [24] and Ryan SM and Nielsen CJ.[3]

NITROUS OXIDE

Nitrous oxide is not as efficient at trapping radiation on a per weight basis compared to volatile agents but remains in the atmosphere exercising its effect for a prolonged period of time. Nevertheless its heat trapping potential is nearly 300 times that of CO_2 and it is estimated to contribute around 6% of radiative forcing by long-lived greenhouse gases [25]. Its atmospheric lifetime is 114 years compared to 1.1 years for sevoflurane, 3.2 years for isoflurane and 14 years for desflurane [24]. As such considering only GWP_{20} for N_2O will understate the potential impact of this agent, and GWP_{100} may be preferred. In addition to its global warming potential, nitrous oxide also has a significant ozone depletion potential [25].

Human sources including fertiliser use and various industrial processes account for approximately 40% of nitrous oxide emissions which continue to rise. The annual increase from 2014 to 2015 of 1.0 ppb is greater than the mean growth rate over the past 10 years. Sherman and Cullen first estimated that worldwide use of nitrous oxide in anaesthesia would contribute less than 1% of total global production, while a more recent estimate by Ishizawa suggested that anaesthesia accounted for 3.0% of total N_2O emissions in the US in 2006 [26,27]. Estimates of global anaesthetic use are not available.

Used as an adjunctive agent in delivery of general anaesthesia, nitrous oxide can substantially increase the GWP_{20} for a given anaesthetic. Ryan and Nielsen calculated the impact of adding 60% nitrous oxide to various agents assuming a FGF of 2 L/min and over 1-MAC hour with sevoflurane, isoflurane and desflurane[3]. The addition of N_2O in the calculation increased the global warming impact of sevoflurane by 590% and isoflurane by 290%. Sparing of desflurane means that the global warming impact for this agent is decreased by 40%. However even when using flows of 0.5L/min with nitrous oxide to minimise the impact of desflurane as much as possible, the climate impact of desflurane remains around 4 or 7 times higher for sevoflurane and isoflurane respectively, compared to using either agent alone.

INTRAVENOUS AGENTS

For intravenous agents issues of direct contributions to climate change through their chemical properties are not the most significant issue. The more substantial issue with intravenous agents may relate to the entire procurement chain, which accounts for up to 60% of healthcare-related climate impact, of which at least half is derived from pharmaceuticals and medical equipment [28]. In considering the impact of a drug over its entire life cycle it is necessary to consider methods of manufacture, packaging, transport to the hospital, energy and materials required for drug delivery, whether it re-enters the environment in an unmetabolised form and waste production and management of unused drugs.

Propofol is the most commonly used intravenous agent reported on in the context of anaesthesia and sustainability. Sherman and colleagues have previously undertaken a life cycle assessment of propofol compared to sevoflurane, isoflurane and desflurane with or without the co-administration of nitrous oxide for each agent [29]. For this work they assumed a 50% wastage rate of propofol and made calculations on a 1 MAC-hour equivalent. They also assumed disposable plastics for necessary equipment to deliver propofol and the energy consumption of the delivery pump. This LCA indicated that desflurane accounted for the largest life cycle greenhouse gas emissions both through release of waste anaesthetic gas and throughout other stages such as manufacturing. Life cycle greenhouse gas emissions were calculated as 15 and 20 times those of isoflurane and sevoflurane respectively when an oxygen/air mix was co-administered. Nitrous oxide again substantially increases life cycle greenhouse gas emissions.

The environmental impact of propofol was nearly 4 orders of magnitude lower than desflurane or nitrous oxide. The main related environmental impacts associated with propofol seem to result from energy requirements to operate syringe pumps, with minor contributions of manufacturing and waste.

Infrastructure

In the USA, hospitals are the largest contributor of health sector carbon emissions, followed by the pharmaceutical industry. The entire sector contributes almost 10% of the country's greenhouse gas emissions, whilst consuming 17% of GDP [30]. Reduction of resource intensity, different choices about infrastructure design, construction and utilisation, and extending financial horizons to include whole system costs can all lead to more environmentally sustainable healthcare. At the same time, aligning financial prudence and environmental priorities may improve healthcare in many different dimensions.

The Sustainable Development Unit (SDU) of the UK National Health System has worked with components of the health system at all scales to pursue a sustainable health system. Such a system is achieved "by delivering high quality care and improved public health without exhausting natural resources or causing severe ecological damage." The SDU has 3 main purposes:

- It rates the progress towards a healthier environment by the health and social care system,
- it prepares communities for resilience in changing times and climates, and
- it has a "triple bottom line" approach where every decision should contribute to healthy lives, communities, and environments.

In 2016, compared with a baseline of 2009, the SDU has achieved a carbon reduction of 11% during a period of growth in activity of 18%. Ambitious targets are for a 25% reduction by 2020, and 50% by 2025 [31].

There are tools to assess the environmental impact of architecture and building. One such tool, Green Star, can be used at the design stage to show the potential environmental impact. Australia has the National Australian Built Environment Rating System (NABERS) and New Zealand has a similar scheme (NABERSNZ). Assessment criteria for these tools include sustainability of site, energy efficiency, water efficiency, materials and resource in construction, indoor environmental quality, and waste and pollution.

The new South Wing of the Flinders Medical Centre in Adelaide, which opened in 2009, was the first healthcare facility in Australia to achieve Certification of Excellence under the Green Star rating tool [32]. Compared with an equivalent benchmark building, it uses 42% less energy, 20% less water, and reduces CO_2 emissions by 4000 tonnes per year. The building incorporates solar hot water and high efficiency air conditioning under individual patient control. There is double glazing, natural light, and passive heating and cooling. Materials were chosen to reduce embodied carbon and minimise volatile chemicals in paints and adhesives. A sustainable supply chain was developed to make future purchasing decisions with regard to environmental priorities. The design incorporates architectural features proven to enhance health outcomes.

The Royal Children's Hospital in Melbourne has a high-performance envelope, harvests rainwater and has on-site wastewater treatment. It incorporates innovative energy generation including renewables, and has both natural ventilation and active chilled beam cooling. Natural light is used where possible, with energy efficient lighting used elsewhere. It is constructed from locally sourced materials, and has maximum recycled content in its precast concrete panels [33].

Beyond energy and resource efficient buildings, there is evidence-based architectural healthcare design that can improve patient well-being and staff satisfaction. Common findings are that quiet surroundings, natural lighting, and views or contact with nature improve patient recovery. Staff also benefit [34]. The costs of constructing a quality indoor healthcare environment may be more than offset by increased productivity from happy and healthy staff [35]. In terms of the triple bottom line, efficient buildings (1) reduce cost to the community, (2) are gentler on the environment and (3) may be designed for improved health of patients and productivity of staff.

Strategies and objectives for such healthcare design would include:

- Improving patient safety. Hospital design with respect to non-slip flooring, proximity between beds and bathrooms, airflow and ability to clean surfaces makes for lower patient injury and infection rates.
- Improving patient outcomes. Design should increase opportunities for staff to observe and interact with patients. Hospital construction that minimises movement of patients with changing acuity reduces handover, and reduces complications [36]. Workflow patterns should inform the design, not the other way around.
- Increasing the satisfaction of patient, family and staff. Sound attenuation and design that separates corridors and lifts for staff and visitors creates a healing environment. Rooms with space for family, and provision for individual patient control of temperature and lighting create patient satisfaction.
- Connection with nature. Unobstructed natural views and sunlight have positive effects on pain, mood, and hospital stay [36], and natural scenery and vegetation have positive effects on staff and patients.
- Meeting expectations of staff and patients, and audit processes of preferences, expectations and satisfaction allows for continuous quality improvement.
- Improving effectiveness and efficiency of staff through standardisation, time in motion data, and design elements.
- Flexible elements of design may allow for future growth, or changes in configuration consistent with newer clinical requirements.
- Active design, a term derived from New York City's Active Design guidelines. Key features include: active transportation (walking, cycling, mass transit), active vertical circulation within buildings (encouraging stair climbing, discouraging lifts and escalators), and consumption of locally grown fruits and vegetables, and tap water. Active design methods promote environmental sustainability and universal accessibility, as well as increased activity [37].

The implementation of Lean theory in the management practices of clinicians may stimulate a rethinking of managing efficiency [38,39]. Lean theory was first developed and described by Toyota in the production of their cars with the aim of improving efficiency and thereby minimising waste while maintaining safety in their manufacturing process. This methodology has been reviewed with respect to emergency department management but not to the provision of anaesthesia services. Its review and incorporation by individual institutions into perioperative and pain services may improve practice efficiency and waste minimisation.

In keeping with Lean theory, rethinking building and workplace design and how these spaces are utilised can help to improve efficiency both in energy consumption and in minimising excessive movement of personnel. For example, reducing electricity use for heating and lighting by improving insulation and allowing windows for natural light, designing buildings to allow for better patient flow (having emergency departments, intensive care units, operating theatres and radiology units on the same level where possible), and designing the workspace so that excessive movements are minimised (e.g. from having intravenous access in the patient on the same side as the anaesthetic drug trolley to locating recycling bins next to set-up trolleys to encourage and ensure recycling occurs). Having single stream recycling with segregation at the recycling facilities is another way of rethinking and encouraging recycling practices through increasing ease for staff and reducing the number of recycling bins required in these small spaces [40,41].

Equipment and Consumables

Operating theatres use large amounts of energy, procure many consumables and produce excessive waste, often contributing to a quarter of all hospital waste [7]. Factors guiding the purchasing of anaesthesia equipment have traditionally been: safety, efficacy, functionality, financial cost, and infection control. A relatively novel approach to medical purchasing is also to consider environmental sustainability [4,7,42]. Often there has been a 'trade off' between a device's financial cost and functionality or infection prevention. Similarly, there may be a tension between the environmental effects of producing a reusable product and the financial costs or infection prevention [42]. The functionality of robust, reusable anaesthesia equipment may align with lower environmental effects compared with less robust and more environmentally problematic single-use equipment. Beyond the direct purchasing of anaesthesia equipment and consumables, anaesthetists on hospital committees are strongly advised to consider the implications of purchasing of other (i.e. surgical) operating equipment.

Infection control concerns vary between countries, leading to differences in anaesthesia equipment use. For example, due particularly to the concerns about variant Creutzfeldt-Jakob Disease, the Association of Anaesthetists of Great Britain and Ireland states that 'The use of such (single-use) anaesthesia equipment is to be encouraged. However, there are problems of cost, storage and disposal of single patient use devices'[43]. There is the added problem of environmental costs, recognising that effective CSSD quality assurance is an integral part of hospital infection control and can be environmentally sustainable.

LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA) is the 'cradle to grave' analysis of the environmental 'footprints' arising from the extraction, manufacture, transport, use, recycling/waste disposal/reuse of equipment or processes [44]. Environmental footprints can be found for energy, carbon (climate change), water, pollutants (aquatic and terrestrial), and ozone depletion amongst others. A general introduction to LCA for the anaesthetist is available in the medical literature [7]. Large, established databases and software [45,46] assist researchers to find the relative environmental costs associated with products/procedures. Rigorous LCA is time consuming and can be financially expensive, thus historically there have been few studies in any medical domain.

However, there have now been LCAs of multiple anaesthesia items, comparing reusable versus single-use variants. A review of five prior studies comparing reusable versus single-use surgical gowns concluded that using reusable gowns had at least a 50% lower environmental footprint than using single-use gowns [47]. A study based in Germany (a country with high renewable electricity generation) showed that the use of reusable linens for drapes instead of disposable drapes was shown to have a lower carbon footprint [48]. In a study of anaesthetic drug trays, it was found that using reusable drug trays had significant financial advantages over the single-use trays (A$5,000 for a 6-theatre hospital in 2009), but that the environmental effects were similar when the hospital location was Victoria, Australia [49]. In 2012, Eckelman and colleagues found that the environmental footprint of using reusable laryngeal mask airways (LMAs) was less than half that of using single-use LMAs for most parameters and the carbon footprint for the reusable LMAs was two-thirds that of the single-use LMAs [50]. On the contrary, in a study comparing reusable and single-use central venous catheter (CVC) insertion kits in Australia the reusable versions of the CVC insertion kits had a carbon footprint more than twice that of the single-use CVC insertion kits, due to coal being the source of electricity in Australia [51]. If the same study had been performed in New Zealand or Europe, the carbon footprint would have found in favour of the reusable CVC insertion kits.

The environmental footprint of all commonly used anaesthesia equipment (face masks, direct and video-laryngoscope handles and blades, breathing circuits, and LMAs) has been studied [51]. In this comparison between two Australian hospitals, one hospital used reusables, the other used mainly disposables. For the 6-theatre operating suite it was found that using reusable equipment saved A$30,000 p.a. (inclusive of all labour/non-labour costs).

Anaesthesia breathing circuits can be used for variable periods of time in different countries. In the USA, it is recommended by the Center for Disease Control that all anaesthesia breathing circuits be disinfected or discarded for each patient even in the presence of single-use bacterial/viral filters [52]. On the contrary, the German Society of Hospital Hygiene (DGKH) and the German Society for Anaesthesiology and Intensive Care (CGAI) jointly recommend that anaesthesia breathing circuits can be used continuously for one week so long as single-use filters are changed for each patient [53]. Several studies have indicated that it is as safe from a microbiological standpoint to change/wash anaesthesia circuits weekly versus daily [54,55]. Using reusable circuits versus single use circuits saves money, although this is minor when washed weekly, and once again the environmental footprint will depend upon the source of electricity,[51] being strongly in favour of reusable circuits in NZ. ANZCA PS28 Guidelines on Infection Control does not comment upon the duration of use of anaesthesia breathing circuits, provided that each patient receives a separate single-use filter.

These life cycle studies indicate that using reusable anaesthesia items appears to consistently save money when compared to single-use equipment, but the environmental effects depend very much upon the source of electricity. Furthermore, efforts to improve the efficiency of hospital equipment (washers and sterilisers) used for cleaning reusable items can have considerable beneficial effects, both financially and environmentally. For example, improving hospital steam steriliser load efficiency and a ‘switch off the steriliser’ policy when not in use can save large amounts of money, electricity and water [56,57].

Rational Use of Diagnostic Tests and Prescribing

Environmental sustainability is also related to clinical inefficiencies in the provision of health care, such as interventions that do not meet patient expectations or provide the desired outcomes [38,58]. These include unnecessary activity by both patient and staff movement, maintenance of stock levels, excessive waiting times, and the over-ordering of investigations and interventions [39,58]. If waste and value are linked, minimisation of inefficiencies increases the value of the services we provide. Programs such as Choosing Wisely have been introduced in Australia and New Zealand to improve clinical care while promoting a rational use of resources. The UK’s Academy of Medical Royal Colleges published a report “Protecting resources, promoting value – A doctor’s guide to cutting waste in clinical care”[38] 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 [10,39].

The environmental impact of diagnostic tests and prescriptions is primarily generated from the production of (often single-use) medical items and medications, transport and procurement, and waste disposal. Reducing the number of unnecessary diagnostic tests and prescription of drugs can result in significant reductions to the overall environmental footprint.

Pharmaceutical preparation and manufacturing (along with surgical and medical equipment manufacturing) have been reported to have the greatest ozone depletion effect of all health sector activities in the USA, (almost 25% each of total)[59]. In regard to morphine it appears that the packaging and sterilisation contribute to the greatest greenhouse gas contribution of its life cycle assessment [60].

Waste management

Waste can be defined as a substance that’s discarded, emitted or deposited in the environment so as to cause an alteration in that environment; any discarded, rejected, unwanted, surplus or abandoned substance; any discarded, rejected, unwanted surplus or abandoned substance that’s intended for recycling, reprocessing, recovery or purification [61]. This waste may be general waste, recyclable waste or clinical waste [62]. Clinical waste is waste that has the potential to cause disease, sharps injury or public offence, including but not limited to cytotoxic waste, pharmaceutical waste, chemical waste, radioactive waste and laboratory waste. The type of waste determines how it's treated and its final destination: landfill, recycling, treatment, biodegradation, incineration, storage or transfer [63].

Reducing waste is an important and key component in improving environmental sustainability in anaesthetic practice and mitigating climate change [38,58,64]. The Australian Government has a National Waste Policy with the aims of improving efficiency resource use and reducing the environmental impact of waste management in order to assist with and provide strategies in reducing waste generation [65]. Operating rooms generate 20-30% of total hospital waste and of this, 20-25% comes from anaesthetic services specifically [4,64,66]. Unfortunately, waste production, including the production of hazardous waste, is increasing and our current efforts are not keeping up [63,67-69].

There are many different ways in which waste production can be reduced: taking responsibility for waste, reduce, reuse, recycle, rethinking and researching [4,5,7,40,70,71]. An alternative approach which addresses reducing clinical inefficiencies utilises the Lean theory [39].

RESPONSIBILITY AND STEWARDSHIP

Taking responsibility is the first step in reducing waste production [5,38,65]. Responsibility doesn't just fall to the individual or organisation. It comes down to all parties from individuals, hospitals/businesses and governments to ensure that all steps are taken to manage and reduce waste in a safe manner throughout products and services entire lifecycle.

Barriers to waste management are many and varied. Reasons postulated include lack of knowledge and facilities, convenience and logistics and a lack of leadership [5,66]. Clinical and pharmaceutical waste contributes 1.4% to Australia's hazardous waste production, according to the Hazardous Waste in Australia Report 2015 [63]. The fate of this waste includes incineration (35%), chemical and physical treatment (28%), storage (18%) and landfill (18%).

REDUCING WASTE PRODUCTION

Anaesthetists generate a large proportion of operating theatre waste [4,64]. Reducing waste production is "grass roots" waste management and the first step in reducing our environmental impact.

Having fewer consumables to discard is one means of reducing waste production: ordering less stock to ensure stores remain within expiry dates and aren't being discarded unnecessarily [70,72].

Opening consumables only when they are needed also reduces the amount of waste produced, in addition to reducing wastefulness [4,66,70,73]. This can apply to both drugs and equipment. Drug waste can have a significant impact on the environment as it has been shown that the procurement of pharmaceuticals and medical supplies contribute more to carbon emissions than total building energy use or travel due to the financial and environmental costs of manufacturing, packaging, transport and disposal [70].

Unnecessary drug preparation contributes to environmental pollution and waste from both a manufacturing and disposal point of view, not to mention the financial costs of unused medications [72,73]. The use of prefilled pharmaceutical syringes reduces the amount of pharmaceutical waste produced as drugs are not opened and drawn up unnecessarily, rather they are opened only when required [4]. Reducing wasted drugs can significantly reduce our environmental impact. Propofol is arguably the most commonly used drug anaesthesia practice and Mankes has previously reported a wastage rate of 32% in a hospital operating suite, accounting for 45% of all drugs wasted [72]. Simply reducing the size of drug vials available can impact on drug wastage, as shown in an audit of propofol use [72]. This audit showed that limiting the availability of propofol vials to the smallest available size (20mL) reduced the amount of propofol wasted from 29.2mL/day/bin wasted to 2.8mL/day/bin, thereby reducing financial waste and potential environmental contamination.

Preparing endotracheal tubes and laryngeal mask airways “just in case” is another example of waste which can be avoided in the same way as pre-drawing up medications. Avoiding over-frequent changing of anaesthetic machine tubing can also reduce the amount of waste produced and still provide safe anaesthetic [54,55].

Reformulating pre-fabricated kits (for example cannulation kits or dressing packs) so that they only contain the products required can reduce the wastage of unnecessary items. Reducing the amount of packaging material is the responsibility of manufacturers, however we have the ability to choose materials with minimum packaging which may force the hand of manufacturers in order to maintain competitiveness [4].

Reducing paper use reduces the environmental impact of anaesthetic services and paper products should be avoided where possible [70]. Methods for achieving this are through the use of electronic records (being mindful that there is an environmental impact to this alternative), avoiding printing or printing double-sided where needed and re-using paper that’s been printed on one side only (caution: confidentiality). The use of recycled paper diverts paper waste from landfill which is a significant contributor of greenhouse gases [70].

Anaesthetists use large amounts of plastics for service provision – from airways, tubing and lines, to syringes, vials, fluids. When not recycled or reused, these contribute a high volume to landfill. They may leech harmful chemicals into the environment when disposed of in this manner and are a source of dioxin when incinerated [41]. Any reduction in the use of plastics will mitigate these effects and reduce the environmental impact of anaesthetic services.

Water is a resource which needs to be managed in order to reduce waste [41]. In many areas, water availability is becoming scarcer and it frequently has a monetary value attached to it as desalination is more frequently being utilised to source this natural resource [74]. More emphasis must therefore be placed on its conservation. This includes the use of water aerators to reduce the amount of water used for the same apparent volume, fixing leaking plumbing, motion-sensitive automatic surgical taps, and ensuring maximum capacity of washers (both in equipment and laundry cleaning) [70]. With respect to consumables, water usage can also be reduced by either choosing products whose manufacturing or reprocessing utilises minimum water requirements [74].

Reducing energy consumption can have positive impacts on the anaesthetic carbon footprint, regardless of the energy source [75]. This can be achieved again through mindful choosing of consumables whose manufacturing or processing is energy efficient [7,50,74]. Turning off equipment and lights when not in use provides a self-explanatory means of reducing energy consumption. Ensuring medical facilities are energy efficient through improved design reduces both energy consumption for heating and cooling and assists with both mitigation and adaptation to climate change via less production-related pollution and greenhouse gas emissions [75,76].

REUSE

There is a trend to an increase in use of disposable equipment used in anaesthesia [4]. This may be due to many factors including convenience, marketing and perceived financial savings and sterility and cleanliness issues. In general, having reusable or reprocessed equipment and consumables reduces the environmental impact of anaesthesia and should be an attractive option for health care facilities as reusing and reprocessing often saves money [5,7,66]. In order to specifically assess this, full lifecycle assessments of disposable items and their re-usable counterparts need to be performed [5,7,70,77]. The use of re-usable operating room textiles, laryngeal mask airways, and central venous line insertion kits have been assessed and it has been found that the use of reusable textiles and LMAs is preferred from both a financial and environmental standpoint, though this is not the case for CVC insertion kits [47,50,74].

RECYCLE

Recycling has many benefits both economically and in mitigating the effects of climate change on the environment, though it should be noted that compared to reducing waste production and reusing items, it is less energy efficient [5,69-71]. Recycling allows the diversion of waste from landfill to other products whether it be reprocessing into the same product (e.g. paper recycling), or reproduction into new products through the waste product being used as raw materials. From an environmental standpoint, manufacturing goods using recycled products as raw materials uses less fossil fuels and so has a smaller contribution to the production of greenhouse gases and climate change. It also means less deforestation for the production of paper production, less mining for metals and reduced need for oil for plastics production [5]. The biodegradation of landfill generates methane which is a greenhouse gas [68,69,71]. For products which would otherwise be incinerated, recycling releases less carbon dioxide into the environment [69,71]. Diverting recyclables away from landfill reduces leachate and potential groundwater contamination which can occur at landfill sites [69].

From a financial point of view, recycling also saves money [4,70,71]. An audit conducted in a US hospital revealed savings of $4672.88 over their 6-month audit period from the addition of single-stream recycling (recyclables segregated at the recovery facility) [71]. The recycle bins were purchased on a grant, however payback on these was completed in under a year. The audit was also able to show energy conservation in this period. Compared to landfill disposal, recycling has an economic advantage of job creation through its labour intensive processing through the transport of recyclable waste, sorting and transformation of materials [78]. Any potential costs of transporting and disposal of recyclable waste may be mitigated (depending on the area) by on-selling these potential raw materials to recycling facilities [4].

Although recycling reduces the carbon footprint of anaesthesia, consideration should also be made for preferentially purchasing products that are made from recycled materials and whose environmental impacts have been calculated as being low [71].

Up to 25% of operating theatre waste is produced by anaesthesia and up to 60% of this is recyclable [4,5]. When surveying anaesthetists there is a strong desire for recycling to occur however it is felt that multiple barriers to recycling exist [4,5,66]. These barriers include a lack of knowledge, convenience, absence of recycling facilities, lack of management support, leadership or encouragement in this area and concerns regarding infectious contamination.

Most waste can be recycled if not contaminated by body fluids. Items which can be recycled include [4,70].

- Paper and cardboard
- Blue surgical/equipment wrap
- Plastics
- Glass, including drug vials as drugs remain present in only small amounts and the incineration temperatures are sufficient to render drugs inert
- Batteries
- Fluorescent light bulbs
- Electronics under e-Recycling programs

It is important to ensure that waste which is destined for recycling isn't contaminated as it won't be accepted by the recycling facilities and that entire waste haul is then treated according to the highest level of risk [61]. This then becomes a costly exercise both environmentally and financially and may hinder recycling facility relationships.

RETHINKING WASTE MANAGEMENT

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. Given the amount of change required to reduce and reverse current environmental sustainability trends, the development of policies on a national and institutional level that encourage rather than hinder waste management processes is important [5,65].

In contrast to single stream recycling, it is important for other waste, specifically contaminated waste and sharps, to be separated and discarded appropriately. To reinforce the above, waste is managed according to the highest level of risk. There are higher costs associated with the disposal of medical waste both financially and also ecologically due to the processing needed (incineration or treatment) prior to final disposal [4,61,62]. Some hospitals don't have a service for removing such waste and so contractors are employed at a higher cost [79]. Princess Alexandra Hospital has demonstrated that appropriate segregation of clinical waste from general waste can result in a 60% reduction of waste disposal costs[80]. Another example of judicious segregation producing savings, both financially and environmentally, is the disposal of sharps. The management of sharps waste is financially and environmentally costly due to the processing required (maceration/autoclaving). The reduction in the volume of sharps waste produced by ensuring only sharps are located in sharps bins (needles and easily broken glass medication vials) reduces the speed in which these receptacles are filled and require energy-intensive processing.

Drug disposal is another important means of reducing environmental impact as they may contribute to water table contamination and toxicity if incorrectly disposed [40,72,81]. This is a particular problem with propofol for example, as it is poorly biodegradable, accumulates in fat and is toxic to aquatic life if leaching into water occurs. It can only be destroyed by high temperature incineration – squirting left over propofol into sharps bins which are incinerated is one method of ensuring it is adequately destroyed without contaminating landfill and water tables. This method of drug destruction is also recommended for local anaesthetic agents [72]. Ephedrine is also toxic to fish and aquatic invertebrates though no recommendations have been made for its disposal.

Away from the clinical environment, other methods that can be considered in waste production and management include having composting facilities available in hospital lunch rooms [70]. Though this doesn't necessarily reduce the amount of waste produced, it does change the way in which it is disposed and can be reused in hospital gardens as fertiliser, thereby reducing the cost to the hospital of transport as well as potentially reducing the gardening and maintenance costs by reducing the need to purchase processed fertilisers. Lunch rooms can also do away with recycling costs by eliminating the use of single-use kitchenware (cups, crockery, cutlery) in favour of staff providing their own reusable items.

Finally, 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 [5,7,62,70,77]. This may include researching technological advances for ways in which waste generation can be reduced, or re-usable products can be used in a sustainable way to increase both product manufacturing and recycling efficiencies.

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ANZCA Council approved the drafting of this professional document in November 2016 and the membership of the document development group, comprising:

Dr Scott C Y Ma FANZCA (lead, SA)
Dr Rob Burrell FANZCA (NZ)
Dr Eugenie Kayak FANZCA (Vic)
Dr Forbes McGain FANZCA (Vic)
Dr Vanessa Percival FANZCA (WA)
Dr Andrew Weatherall FANZCA (NSW)
Dr Ingo Weber FANZCA (SA)
Dr Peter Roessler FANZCA (DPA Professional Documents, Vic)
Kate Davis (Policy Unit, ANZCA)

RELATED ANZCA DOCUMENTS

PS07 Guidelines on Pre-Anaesthesia Consultation and Patient Preparation

PS28 Guidelines on Infection Control in Anaesthesia

PS51 Guidelines for the Safe Management and Use of Medications in Anaesthesia

FURTHER READING

American Society of Anesthesiologists', Environmental Sustainability
https://www.asahq.org/resources/resources-from-asa-committees/environmental-sustainability

Maughan D, Ansell J. Protecting resources, promoting value: a doctor's guide to cutting waste in clinical care [Internet]. Academy of Medical Royal Colleges, Nov 2014 Available from: http://www.aomrc.org.uk/wp-content/uploads/2016/05/Protecting_Resources_Promoting_Value_1114.pdf

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