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Review

Waste management in Belgian operating rooms: A narrative review

N. Magasich-Airola[1], Q. Souberbielle[1], L. L'Hotel[2], M. Momeni[1], R. Tircoveanu[1]

[1]*Department of Anesthesiology, Cliniques universitaires Saint-Luc, Université catholique de Louvain (UCLouvain)/ Institut de Recherche Expérimentale et Clinique (IREC) ,Avenue Hippocrate 10, 1200 Bruxelles, Belgium;* [2]*Department of Anesthesiology, Centre Hospitalier d'Ardenne (CHCA), Libramont, Avenue d'Houffalize 35, 6800 Libramont-Chevigny, Belgium.*

Corresponding author: Magasich-Airola N, Cliniques Universitaires Saint-Luc, Avenue Hippocrate 10, 1200 Brussels, Belgium. E-mail : natalia.magasich@uclouvain.be

Abstract

Climate change is caused by the accumulation of greenhouse gases (GHG) that trap heat in the atmosphere, resulting in rising temperatures. The healthcare sector is a significant contributor to GHG emissions, accounting for a global average of 4.4% of total emissions, rising to 5.5% in Belgium. The operating room (OR) is disproportionately responsible for 40% of these emissions. The carbon footprint of the OR is mainly composed of waste production, energy consumption, and the emission of anesthetic gases. It is estimated that the OR generates 20 to 30% of hospital waste.

Therefore, anesthesiologists have shown an increased interest in sustainable healthcare, particularly in waste management.

This narrative review aims to explain healthcare waste management in the Belgian operating theatre and to explore evidence-based approaches to a more sustainable practice based on the waste hierarchy "reduce, reuse, recycle".

Keywords: **Sustainable anesthesia, Waste management, Green operating room.**

Introduction

The 2023 report of the Intergovernmental Panel on Climate Change (IPCC) shows an increase in Earth's surface temperature of 1.1°C in the 2011-2020 period compared to the 1850-1900 period. The report declares this to be 'the biggest global health threat of the century'[1]. This anthropogenic climate change arises from human activities that produce enormous amounts of Greenhouse Gases (GHG), which accumulate in the atmosphere contributing to global warming.

Healthcare sector is responsible for 4.4% of GHG emissions[2]. This percentage is higher for high-income countries, ranging up to 5.4% in the UK and 10% in the United States[3]. If the global health sector was a country, it would be the fifth largest emitter of GHG on the planet[4].

Based on the international Non-Governmental (NGO) Health Care Without Harm's report on the climate footprint of health care, Belgium's health care footprint is 5.5% of national emissions, which is higher than the world's average of 4.4%. Datas from Flanders show that about 10% of CO2 emissions come from the healthcare sector and 5% of the industrial waste is produced by this sector[5].

The operating room (OR) is disproportionally responsible for 40% of these emissions. The three main components of this carbon footprint are waste production (Considering both solid and liquid waste, represented by drugs), energy consumption, and the emission of anesthetic gases[6]. These last two points will not be addressed in this review. With regard to anesthetic gas emissions, the Belgian Society of Anesthesiology, Resuscitation, Perioperative medicine and Pain management (BeSARPP) has just published recommendations on responsible and sustainable use of inhaled anesthetics[7].

The OR generates 20-30% of hospital waste[8]. Actually, each operating theatre can produce up to 2,500 kg of waste per year[9]. Therefore, a single standard surgical operation generates, on average, as much waste as a family of four in a week.

Anesthesiologists have shown an increasing interest in the environmental impact of their practice and the number of publications in sustainability has been steadily increasing in recent years.

The aim of this narrative review is to focus on waste management in the OR (and in particular the Belgian ORs), by clarifying the waste classification and exploring evidence-based approaches using the "Reduce, Reuse, Recycle" hierarchy of waste management.

Type of waste

Healthcare Waste Classification

The World Health Organization (WHO) categorises healthcare waste into two types: hazardous medical waste (HMW) and non-hazardous medical waste (NHMW).

When segregation is properly done, HMW accounts for 15% and can be further divided into infectious waste (10%) and non-infectious hazardous waste (5%). HMW comprises hazardous material (sharps, needles), infectious waste, pathological waste (human tissues, organs, and fluids), pharmaceutical cytotoxic waste, chemical waste, and radioactive waste. Therefore, the waste included in this category is called hazardous and may imply a danger to individuals (identified by a yellow box or yellow bag in Belgium).

The remaining NHMW or general waste accounts for 85% and is assimilated to domestic waste (identified by a grey bag in Belgium) (Figure 1 and Table I).

In Belgium waste management falls under the regional competence of the Brussels Capital Region, Flanders, and Wallonia. Each region has its own waste management planning and statistical reporting entities[10], with slightly modified waste definitions. However, all three regions adhere to the principles of WHO classification (Figure 2).

Waste segregation

It is important to note that approximately 85% of hospital waste is non-hazardous. However, in the operating theatre, most non-hazardous waste is incorrectly classified as hazardous[11]. This results in significant environmental impact and unnecessary high costs due to high-energy disposal processes.

In Belgium, both general and hazardous waste are sent for incineration. The difference between the two lies in the cost of treatment, with hazardous waste being up to five times more expensive due to the potential danger it poses to waste workers and the need for protective measures during handling and transportation. Treating a tonne of hazardous waste incurs additional costs and produces higher levels of CO2 emissions. Distinguishing general and hazardous waste is therefore crucial.

Educating staff on proper waste segregation is a cost-effective and sustainable solution[12]. Proper segregation of waste enables the differentiation between recyclable and non-recyclable materials, resulting in a reduction of waste volume that is incinerated. This practice protects resources and allows for carbon savings.

Implementing the concept of the 3 R (Reduce, Reuse, Recycle)

The basic principles of waste management are based on a strategy that applies to all levels of healthcare eco-design. Waste reduction is based on the "3Rs" principle: reduce, reuse and recycle. These three actions are ranked according to an order of preference known as the 'waste hierarchy'. In this inversed pyramid, the most preferred methods are placed at the top and the least preferred at the bottom, according to their overall benefits and environmental impacts (Figure 3).

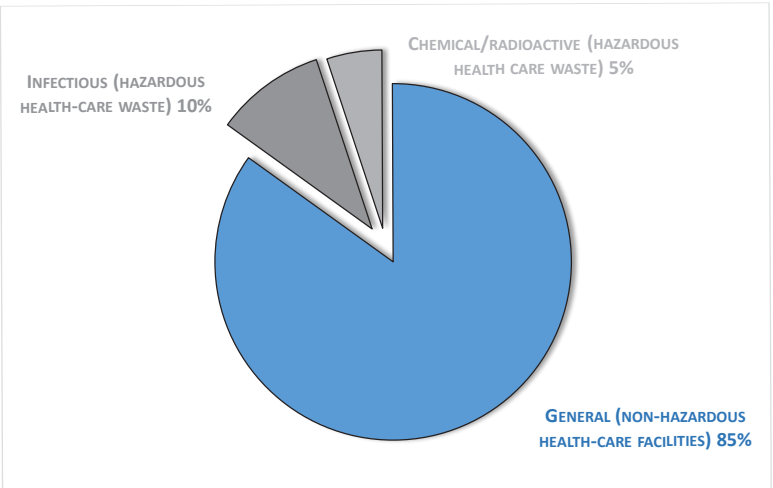

Fig. 1 — Typical waste compositions in health-care facilities (from WHO).

Table I. — Categories of health-care waste (from Safe management of wastes from health-care activities- second edition - WHO 2014).

Waste category	Descriptions and examples
Hazardous health-care waste (15%)	
Sharps waste	Used or unused sharps (e.g. hypodermic, intravenous or other needles; auto-disable syringes; syringes with attached needles; infusion sets; scalpels; pipettes; knives; blades; broken glass)
Infectious waste	Waste suspected to contain pathogens and that poses a risk of disease transmission (e.g. waste contaminated with blood and other body fluids; laboratory cultures and microbiological stocks; waste including excreta and other materials that have been in contact with patients infected with highly infectious diseases in isolation wards)
Pathological waste	Human tissues, organs or fluids; body parts; fetuses; unused blood products
Pharmaceutical waste, cytotoxic waste	Pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals; Cytotoxic waste containing substances with genotoxic properties (e.g. waste containing cytostatic drugs – often used in cancer therapy; genotoxic chemicals)
Chemical waste	Waste containing chemical substances (e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents; waste with high content of heavy metals, e.g. batteries; broken thermometers and blood-pressure gauges)
Radioactive waste	Waste containing radioactive substances (e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources)
Non-hazardous or general health-care waste (85%)	Waste that does not pose any particular biological, chemical, radioactive or physical hazard

Reduce

"Less is more". Reduce concerns methods that decrease the waste of environmental resources by avoiding waste generation. This concept has been shown to be both ecologically and economically sustainable.

Reduce liquid waste (drug waste)

Drug wastage is a significant concern in anesthesia as it contributes to environmental contamination and increases healthcare costs.

Studies have shown that between 20% to 50% of prepared drugs are never used and must be discarded, resulting in the production of hospital waste[13]. This wastage represents 46% of the total cost of drugs. A higher percentage of waste occurs more frequently with emergency drugs that are prepared for preventive purposes and which are finally not used. Propofol is associated with the highest volume of waste[14].

All these drugs have a negative impact on the environment, which can be evaluated using the PBT (Persistent, Bioaccumulative and Toxic) index[15]. This index measures the impact of medicinal products on aquatic environments based on three criteria: Persistence, Bioaccumulation, and Toxicity. Each item is scored from 0 to 3, resulting in an index ranging from 0 to 9. Propofol has a PBT index of 6/9 (3-0-3) because it is non-biodegradable in water and highly toxic to aquatic organisms.

It is considered one of the most harmful drugs due to its high bioaccumulation and direct toxicity to

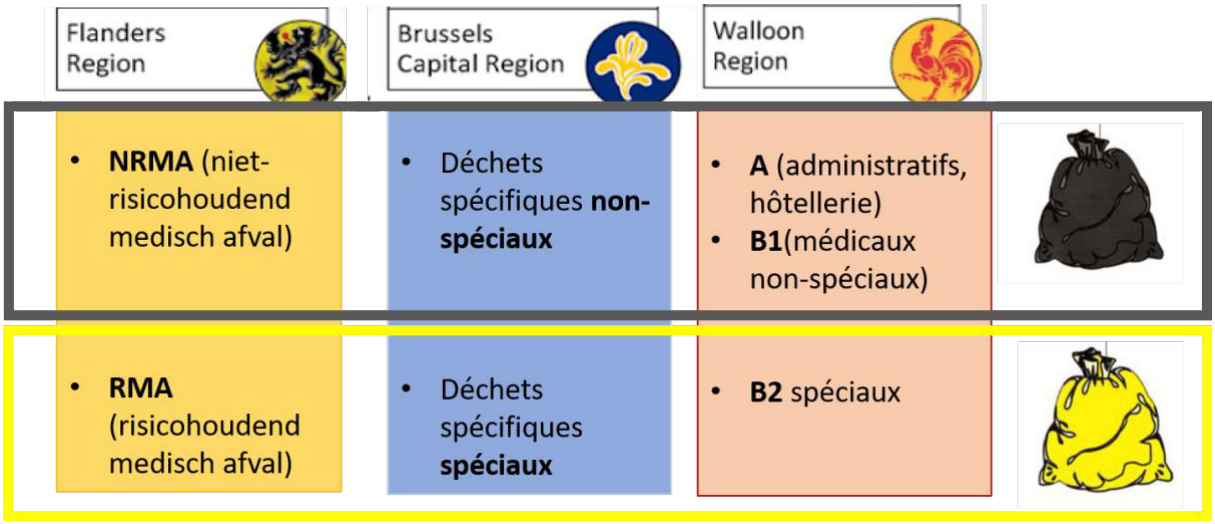

Fig. 2 — Waste definition according to each region.

aquatic organisms. Its lipophilic structure means that it is not biodegradable and requires incineration for complete destruction. The potential contamination of surface waters by propofol is a significant concern due to the large amount that is discarded or wasted. Although it is the second most administered drug by mass in anesthesia[16], its effects on the aquatic environment have not been rigorously assessed. Furthermore, the effects of chronic exposure to low doses of other commonly used anesthetic drugs, such as cefazolin, sugammadex, lidocaine, muscle relaxants, and opioids, on the aquatic environment have not yet been evaluated and require further research.

Therefore, effective medication management in the OR is crucial to minimise wastage. The best way to reduce medication waste is to limit preparation to only the medications that are planned to be used. Additionally, using only the smallest vials of propofol (20 mL) and reserving the larger ones (50 and 100 mL) for very long cases can also be an effective strategy[17].

To further decrease medication waste, the use of prefilled syringes can be considered. Using prefilled syringes can decrease waste as they can be returned to stock and have a long shelf life, unlike medication drawn up from a vial. In the absence of prefilled syringes, keeping emergency ampoules and syringes on hand can provide a suitable alternative for fast preparation when needed.

Reduce solid waste

Healthcare sector should have a reflexion on medical overuse (exams, interventions, medications,…). In the operating theatre, this means also avoiding the overage of materials. An effective way to improve the environmental footprint of the operating theatre is to reduce the amount of waste generated. When preparing operating tables, material is often desterilised without being used. Waste can be reduced by avoiding opening of unnecessary products.

In a study of 152 surgical procedures, including urology, gynecology and gastrointestinal surgery, Chasseigne et al. analyzed the costs of wasted supplies (opened and unused devices). They found that significant amounts were wasted, up to 20% of the budget allocated to consumables, representing a loss of 100,000 euros per year[18]. In more than 30% of cases, the waste is due to a lack of anticipation of the surgeon's needs. The authors therefore propose a "just-in-time" model for elective surgery. The surgeon requests the equipment he/she needs at the right time if it is not in a specific package.

Regular optimisation of surgical and anesthetic kits is another way to avoid unnecessary waste. For standard procedures, sterile kits containing surgical or anesthetic equipment are assembled either by the hospital or by a medical firm. The amount of material in these kits should be limited to the lowest common denominator for users. On the one hand, this reduces waste and the generation of unnecessary waste due to the presence of equipment that is rarely or never used. To be noted, the creation of a single package for a type of surgery, in which all the equipment is sterilised at the same time, avoids the production of waste packaging that would be generated if each device had to be sterilised separately. These measures must be adapted to the protocols of each centre and require further research[19,20,21].

Reuse

The primary cause of waste overproduction is the shift from reusable to single-use products in recent decades. Disposable devices have become widespread, initially to address concerns about the infectious risk of reusable equipment, and later became popular due to ease of use. However, WHO has clearly stated that there is no clear evidence to support a difference in terms of surgical site infection or wound contamination between disposable and reusable items22. Therefore, it is necessary to examine the environmental impact of both.

Life Cycle Assessment (LCA) has recently been used to quantify and compare the ecological footprint of reusable and single-use devices. It is a comprehensive method to measure the cradle to grave impact of a product on various environmental outcomes. Methodology includes natural resource extraction, manufacturing, packaging, transportation, use /reuse, and waste management strategies[23]. LCA is therefore a valuable tool that healthcare facilities should use to improve their environmental impact. It should be considered when selecting medical equipment for surgical/anesthesia services[24].

Kampman et al. recently conducted a review of available publications comparing the environmental impact of reusable and disposable equipment used in the OR. Studies were conducted on a range of equipment including laparoscopy instruments, ureteroscopes, vaginal specula, sterilisation canisters, needle containers, scissors, spinal fusion sets, anesthetic trays, central venous catheterisation kits, surgical drapes and gowns, head caps and anesthetic equipment such as laryngeal masks, facial masks, airway circuits, and laryngoscopes. The review unanimously concluded that reusable equipment has a lower environmental impact[25].

However, the selection of reusable materials should not be automatic, but should be based on a rigorous prior evaluation. The carbon dioxide

emissions from disposable products depend mainly on the type of energy required for their mass production, while the carbon footprint of reusable products comes mostly from repeated washing cycles. The environmental impact of reusable medical devices is determined by the number of times they are reused, the type of cleaning (low-level disinfection or high-level disinfection), the sterilization method (steam or ethylene oxide), and the waste disposal management[26].

Given that the economic criterion is also a key parameter in decision-making, it must be estimated correctly without favouring disposable items, which are cheaper to purchase and have no maintenance costs. When using reusable laryngoscopes, Sherman et al. demonstrated that in a hospital performing 60.000 intubations per year, financial savings range from $675.000 to $869.000, depending on the type of cleaning used (disinfection or sterilization)[27]. The measures to preserve the sterility of reusable equipment must be rigorously defined, based on recommendations such as those from the WHO. Non-invasive devices that are in contact with intact skin, such as blood pressure cuffs and stethoscopes, can be reused after simple cleaning. Semi-invasive devices, such as laryngoscope blades and masks, that are in contact with mucous membranes or body fluids require a high level of disinfection before reuse[28]. Maintaining the asepsis of anesthesia breathing circuits requires weekly washing or replacement[29,30].

Recycle

If reducing and reusing are not feasible, then recycling should be considered.

It is important to note that recycling requires significant energy consumption, but it is still less resource-intensive than producing new products and is a better alternative to incineration or landfill disposal.

Additionally, 85% of waste produced in the OR is similar to household waste and therefore potentially recyclable. Appropriate segregation of general solid waste in ORs into true waste and recyclable materials can reduce both the cost of discarding the waste and its harmful impact on the environment. It is estimated that 40 to 60% of OR waste is recyclable[31].

Staff may be hesitant to sort waste due to the risk of exposure to infectious materials. It is worth noting that 80% of waste is produced during case preparation, prior to the patient's arrival into the OR[32]. Sorting waste during the case preparation phase, when every device and packaging is "clean" can alleviate concerns about infectious contamination, and this method has also been shown to reduce the amount of waste produced by 50% on an annual basis[33].

Potentially recyclable anesthesia-related materials are plastics, papers, glasses, metals and batteries but the specific subset of materials that can be recycled varies considerably not only between institutions but also between countries.

Rethink, Research

Two additional R's can be considered in green practice strategies: Rethink and Research.

Sustainable initiatives cannot be implemented without cultural change and leadership. When considering equipment purchases, it is crucial to take into account their LCA. Manufacturers are encouraged to provide comprehensive information on the environmental impact of their products. By encouraging audits and quality improvement activities, staffs can evaluate their practices and monitor the impact of environmental actions[34]. Education plays a crucial role in ensuring the long-term success of sustainable initiatives. Information and training should be proposed to OR users on annual basis[35]. Furthermore, environmental sustainability should be included in anesthesia training education programs and in continuous professional development.

As interest and publications on sustainable development in health care are increasing in the medical community, research should be encouraged. Independent studies are needed to better understand the environmental impact of health care activities[36]. Life cycle analysis and cost comparison studies of materials and equipment could help users and institutions to make informed choices while maintaining safe and high-quality care. Research should also include the development of devices that minimize environmental effects[37].

Conclusion

Given the urgency of global warming, it is imperative to take steps to reduce the environmental impact of healthcare activities and to look after human resources.

The operating theatre has a disproportionately large carbon footprint compared to the rest of the hospital. One of the contributors to this problem is the generation of waste.

The operating theatre is also the nerve centre of a healthcare facility and as such can set an example and engage other departments in a virtuous circle.

Many actions to reduce the environmental impact of waste in the operating theatre can be easily taken by those working in this area. Significant changes can be made by improving segregation, reducing

waste and wastage, and developing recycling protocols. These actions can also help to raise awareness and change attitudes.

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