

**Review Article**

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Challenges of Going Green in the Operating Room

Cindy B Yeoh^{1*}, Kathleen J Lee², Shalini Mathias³, Luis E Tollinche¹¹Memorial Sloan Kettering Cancer Center, Department of Anesthesiology and Critical Care Medicine, USA²Roswell Park Comprehensive Cancer Center, Department of Anesthesiology and Pain Medicine, USA³University at Buffalo, Department of Anesthesiology, USA***Corresponding author:** Cindy B Yeoh, Memorial Sloan Kettering Cancer Center, Department of Anesthesiology and Critical Care Medicine, USA.**Received Date:** May 17, 2020**Published Date:** June 04, 2020**Abstract**

The environmental debate continues to expand in the realm of healthcare, resulting in increased scrutiny of the impact of material waste and gas emissions in the operating room (OR). In a single day, ORs can contribute up to 2000 tons of medical waste, mostly in the form of disposable medical supplies. We review the major challenges associated with "going green" in the OR.

Introduction

Hospitals in the United States produce more than 2 million tons of waste annually. As a result, adopting more sustainable "going green" practices through cost-effective initiatives remains high on the agenda of hospitals nationwide. The three pillars of environmental sustainability, "reduce, reuse, recycle," are disproportionately applied in operating rooms (ORs), mainly because much of the waste generated in ORs cannot be reused. As a result, materials reprocessing has become a subject of significant focus for the Food and Drug Administration (FDA), whereby companies are encouraged to innovate next-generation environmentally friendly medical devices [1]. However, the challenge remains in creating cost-effective, reusable items for daily use in ORs. This, amongst other factors, is why the OR has not historically been a target for large scale recycling efforts.

Important elements contributing to the carbon footprint of the OR are the emission of inhalational anesthetics and the use of disposable materials and equipment which contribute to a large amount of waste production. Some have cited poor leadership and staff misconceptions, due to lack of knowledge and training on waste segregation, as barriers to effective greening of the OR. OR

staff often report uncertainty on the recyclability of materials and equipment, thereby only occasionally recycling in the OR, which hinders progress and change [2].

Barriers to Going Green**Waste segregation**

Waste segregation is defined as sorting of waste based on recyclability and hazard risk; streamlining collection, treatment, and recovery processes with the goal of minimizing final waste disposal. In hospitals, waste generated can be separated into regulated medical waste (RMW) and non-regulated medical waste (non-RMW). Regulated medical waste poses potential risk because it has either been contaminated with body fluids, or includes infectious, sharp, pharmaceutical or radioactive agents, and requires special handling and disposal. Conversely, non-RMW does not pose a health hazard and can be handled through regular disposal processes [3]. Given the specific requirements for different types of hospital waste, limits on location and availability of recycling facilities pose additional obstacles to effective waste segregation processes.

Failure to separate infectious waste from clean waste poses a great barrier to recycling. There is a dramatic increase in the amount of waste labeled as infectious, thereby requiring special red bag disposal and incineration. Hospital regulated medical waste (RMW) should not compromise solid or liquid items contaminated with blood or other potentially infectious material. Unfortunately, this type of disposal tends to get overused. Limiting the volume of RMW for disposal leads to substantial dollar and environmental savings for the hospital. Forfeiting the restriction in RMW can result in 500 percent higher sunken costs [4].

There are also concerns about infectious contamination from recyclable material from the OR. Workers in recycling facilities manually sort material and are concerned about exposure to bodily fluids. Recycling facilities will not accept material that has been in contact with a patient. Similarly, recyclable materials which contain residual medication and materials must also be handled as hazardous waste. Currently, recycling technology cannot separate hazardous material from recyclable. Fear of contamination may cause the entire recycling load to be rejected. Due to a lack of sufficient education, an estimated 50-80% of normal waste is disposed of as hazardous waste and incinerated [4].

Cost

Going green also requires high upfront capital costs. These costs are related to the building of new waste recycling units, and establishing of appropriate infrastructure required for pickup, transportation, sorting, cleaning, and processing of recyclables. Additional costs are incurred in the creation and execution of new recycling protocols. This requires an initial phase of staff education and training, followed by planning, implementation, auditing, and ultimately re-education of all hospital staff. These must pass the profit test, and as repeatedly proven in business models, recycling isn't always cost-effective. Akin to wind and solar energy, benefits of going green are well established, but the exorbitant cost of conversion and limited hospital budgets pose barriers to change.

Materials and Equipment

The green OR encourages staff to choose reusable products over disposable ones. Increasing waste is driven in large part by the increasing volume of disposable single use products which are specifically marketed for the OR. The reasons for the transition to disposable items include concerns regarding sterility and infection prevention and the ease of use. Decisions on whether to use reusable vs. disposable products are based on cost and scientific data. There is still wide controversy given the conflicting scientific studies that support both materials with regards to safety, performance, and protection [4]. One of the sentinel articles that centered on disease transmission via cross-contamination of medical devices was published in 1978. With the rise of dangerous multi-drug-resistant organisms, the dangers of transmitting infection by cross-contamination are greater than before. An advantage of using disposables over reusables is that disposable items do not undergo

reprocessing between uses. Device reprocessing has been linked to residual contamination left by reprocessing agents that fail to enter difficult-to-reach areas of reusable devices. Additionally, breakdown of device materials can result in damage and compromise of function which ultimately affects patient safety. Reprocessing can also expose healthcare workers and patients to toxic chemicals [5].

There is a "Life Cycle Assessment: Cradle to Grave Analysis", created as a scientific quantification of environmental impact, to aid physicians in factoring the environment into clinical decision making. Life-cycle assessment (LCA) is a process that involves analysis of the energy and emissions used in the production, use and ultimate disposal of an item. It takes into account raw materials used in manufacture, cleaning, and sterilization during the product's lifetime and finally the cost of disposal to landfill or incineration [6]. Disposable laryngoscope blades offer a good example of how complex the disposable/reusable decision can be. Disposable blades eliminate the risk of cross contamination between patients. They eliminate the costs of cleaning that involve labor, toxic chemicals and natural resources. On the other hand, reusable blades may provide higher quality and reliability which can benefit patients. Reusable blades avoid the ongoing carbon footprint of manufacturing and the substantial bulk waste that disposables contribute.

An LCA comparing reusable versus disposable laryngeal mask airways (LMAs) at Yale-New Haven Hospital demonstrated that reusables fared better on every impact category considered. However, when considering CVP kits, McGain and Naylor C [7], found that although reusable and sterilized CVP kits were less expensive, they were environmentally much more costly – both in terms of CO₂ emission equivalents and water use [4,7].

Inhalational Anesthetics

With the overwhelming data on the greenhouse effects of inhalational anesthetics, the logical response is to switch to total intravenous anesthesia (TIVA). However, the intravenous medications we use during administration of anesthesia can end up in our drinking water directly via the disposal of unused drugs and indirectly via human excretion. 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. Drugs were classified based on environmental risk (the ratio of the predicted concentration to the safe environmental drug concentration), and the environmental hazard (a nine-point index based on Persistence, Bioaccumulation and Toxicity, or PBT index 0-9) [4]. While TIVA decreases vapor use, data suggests that propofol may not be an environmentally sound choice since it has the highest PBT index value of 9 [4]. One must also consider the entire procurement chain of intravenous agents, which accounts for up to 60% of healthcare-related climate impact [6]. In considering the impact of a drug over its entire life cycle, it is necessary to consider methods of manufacturing, packaging,

and distribution. Energy and materials required for drug delivery, re-entry of unmetabolized drug into the environment, waste production, and management of unused drugs must also be accounted for. For example, disposable plastics for necessary equipment to deliver propofol and energy consumption of the delivery pump must be factored into the “going green” equation [6].

Conclusion

It is evident that cost is one of the major barriers to environmental endeavors in the OR. Hospitals around the globe increasingly operate under business models. Efforts to green the OR, while environmentally sound, are often impractical from a hospital’s financial standpoint. Despite this, increased attention to the impact of business decisions on environmental sustainability is guaranteed. Existing solutions may be complicated and likely involve key stakeholders beyond the ORs. However, every attempt should be made to curb waste to reduce the OR carbon footprint. Determining supplies needed on a case-by-case basis through detailed discussion and an OR team approach may be the beginning steps that can lead to an eventual impactful change for a better and greener OR.

Acknowledgment

The authors’ work was supported and funded in part by NIH/ NCI Cancer Center Support Grant P30 CA008748.

Conflict of Interest

No conflict of interest.

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