



(REVIEW ARTICLE)



## How to reduce the carbon footprint: In the operating room, in the hospital, on the planet: The participation of General Oncology Hospital of Athens "Saint Savvas".

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### Abstract

**Introduction:** Nowadays, climate change is seen as a visible threat that we are asked to face every day by posing new political challenges. Hospital waste is estimated at 1% of solid waste and 2.1% of the annual greenhouse gas emissions of each country. More specifically, operating theaters are the main source of pollution coming from Hospitals, with anesthesia departments responsible for 25% of these pollutants.

**Method:** The General Oncology Hospital of Athens "Saint Savvas" and in particular the Anesthesiology Department, in collaboration with the Surgery, participates in the global effort to reduce CO<sub>2</sub> emissions to protect the environment, adopting the 5R program (Recycle, Rethink, Research, Reduce, Reuse) and the ESAIC (European Society of Anaesthesiology and Intensive Care) guidelines "How to reduce the carbon footprint in the surgery, in the hospital, on the planet". Qualitative data analysis was performed on outcomes

**Results:** Decreased desflurane consumption per surgery by -7.31% and overall, in the year 2023 by -1.59%. Reduced battery consumption from -73.89% to -100%. From the money saved, the items of the Anesthesiology Department's medical supply warehouse increased by +16.56%, while the percentage value decreased by -11.39%.

**Conclusion:** With the adoption of the 5R program, it seems that financial and material resources are saved and the consumption of volatile gases per operation is significantly reduced.

**Keywords:** Carbon footprint; Carbon emission; Anesthesia; Surgery; Climate change

### 1. Introduction

Nowadays climate change is seen as a visible threat that we are called to face every day by posing new political challenges (1). In fact, between 2030-2050 an additional 250,000 deaths worldwide are expected from climate change, figures that demonstrate the importance of its immediate response (2).

Health Systems also contribute greatly to the global carbon footprint while governments, with international agreements between nations, have set targets for its reduction (3).

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More specifically, Hospital waste is estimated at 1% of solid waste and 2.1% of the annual greenhouse gas emissions of each country. Operating Theaters seem to be the main source of pollution coming from Hospitals, with Anesthesia Departments responsible for 25% of these pollutants (4).

The General Oncology Hospital of Athens "Saint, and particularly the Anesthesiology Department, in collaboration with the Surgery, participates in the global effort to reduce CO<sub>2</sub> emissions for the protection of the environment, adopting the 5R program (Recycle, Rethink, Research, Reduce, Reuse) (5).

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## 2. Method

The two departments in a joint and collaborative effort adopted the ESAIC (European Society of Anaesthesiology and Intensive Care) guidelines "*How to reduce the carbon footprint in the operating room, in the hospital, on the planet*" (6). The Nurses of the Anesthesiology Department, the Nurses of the Surgery Department and the Anesthesiologists participate in the program. The actions of the program are supported by the Administration and the Financial Department of the Hospital.

The 5R Program includes:

- Recycle: Recycling materials from plastic, paper (cardboards and boxes), batteries and ink cartridges.
- Rethink: Removal of unnecessary materials and tools that will not be used from surgical sets. The preference for sustainable markets. Reducing the length of stay of patients in the Hospital through fast-track surgeries, enhanced recovery after surgery (ERAS) protocols and one-day hospitalization where possible.
- Research: Life cycle analysis of medical devices. The carbon footprint of new practices and technologies. The "green appliances" market.
- Reduce: The reduction of energy consumption. The reduction of printing, paper and document handling. We reduce the unnecessary use of drugs and materials. The reduction of staff exposure to chemicals that disrupt the functioning of the endocrine glands, etc. The reduction of the use of halogenated gases. The use of anesthetic protocols without N<sub>2</sub>O, and low-flow anesthesia with closed circuits. The reduction and separation of hospital waste. The reduction of medical waste and the demand for consumable supplies. Limiting the use of batteries. The analysis of the costs of the procedures.
- Reuse: The reuse of medical devices through special treatment where possible.

In more detail, the actions taken:

- Waste reduction and sorting: Different types of waste were identified and separated based on the category they belong to household, hospital and recyclable. Most of the waste in the operating room is the recyclable, then the domestic, and the least is the hospital. Black household waste bins were placed in each operating theater and blue recycling bins per two operating theaters. Until this action was implemented, the operating theaters were only equipped with red hospital bins, while a black household waste bin was only available in the sterile material preparation areas.
- Reduction of waste of sanitary materials: Any tools that were not used from the reusable sterile sets were removed and these tools were placed to reorganize other sets. The demand for sanitary materials with pre-packaged kits was stopped and their use was replaced by simpler materials with less packaging waste, lower purchase and handling costs and of course lower manufacturing costs.
- Reduction of drug waste: Only the drugs that are to be used were prepared, and in the smallest possible quantity. Where possible, smaller amounts of sera were used, such as in arterial line systems to measure blood BP and CVP. Of course, it goes without saying that we don't throw medicines down the sink.
- Reduction of air pollution from the use of anesthetic gases: Anesthetic protocols are used without the use of N<sub>2</sub>O. Old anesthesia stations were replaced with new and up to date ones that administer anesthesia at low flows. Closed circuits of anesthesia are used and where possible TIVA is used. While for the cases in which the surgery can be performed without the use of general anesthesia, then alternative techniques are preferred, such as neuraxial anesthesia, peripheral nerve blocks, etc. In surgeries that are expected to last more than one hour, the biphasic BIS index is used to estimate the depth of sedation and anesthesia, with which titrated and personalized anesthesia is administered, significantly reducing the consumption of anesthetic agents and therefore their emissions to the environment.
- Reduction of environmental pollution: We replaced non-rechargeable batteries with power-banks in PCA pain pumps, thus benefiting both consumption and disposal. We channeled the common sanitary materials that we did not use to other departments of the hospital (mainly the ICU) and the specialized anesthetic sanitary

materials and drugs to other Anesthesia Departments of Public Hospitals of Attica, through the Supply Office and the Pharmacy. We offer daily French coffee to reduce plastic consumption and promote the use of individual water containers or multi-purpose glasses.

- Culture change: We trained Nurses on ways to reduce waste at every stage of the perioperative process. We have strengthened teamwork and collaboration to combat barriers to the idea of sustainability. Six nurses from the Anesthesiology Department and six from the Surgery were designated as supervisors, with the main role of reminding the other of the program procedures until the changes are integrated into daily practice.

### 3. Results

In the year 2023, 194 more surgical operations were performed than in the year 2022, that means an increase of +6.17% in the number of operations. At the same time, with the changes adopted under the 5R program to reduce the CO<sub>2</sub> footprint, desflurane consumption per surgery decreased by -7.31% and overall in the calendar year 2023 by -1.59%. In addition, battery consumption was reduced from -73.89% to -100%. While with the money that was saved, the types of stocks of the Anesthesiology Department's sanitary material warehouse were increased. Furthermore, with the introduction of new sanitary and medical-technological materials and with the proper handling of the existing materials and medicines we were able to economize.

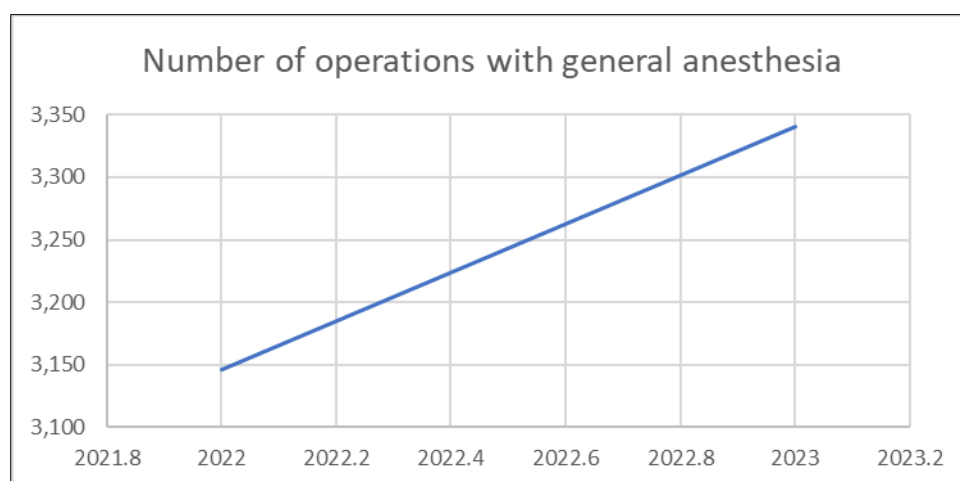
The saving of health resources is indicatively reflected in the value of the warehouse stock items of the Anesthesiology department, although the items increased by +16.56%, the percentage of their value decreased by -11.39%. In practice this means the proper organization of the safety stock of consumables according to standards of organization and management of the stock of the material warehouse, which were estimated after calculating the time of supply in terms of time of consumption and use.

A qualitative data analysis was performed for the above results.

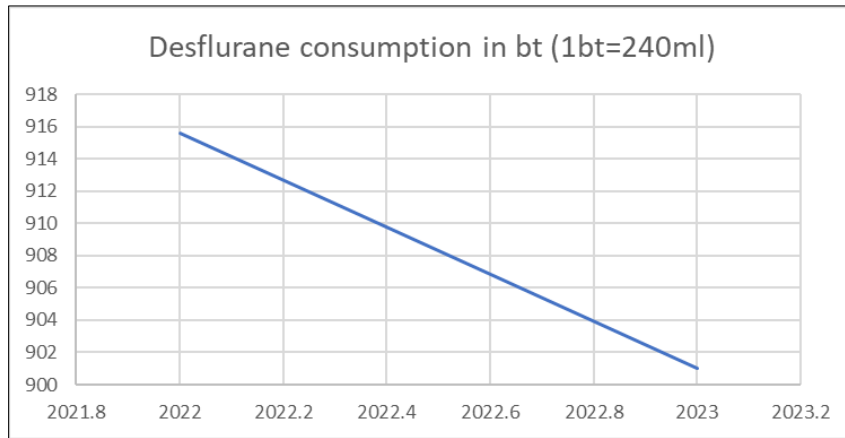
**Table 1** Comparing the years 2022 and 2023 with percentages of benefit changes

	2022	2023	Total amount	Percentage
Number of operations with general anesthesia	3.146	3.340	194	+6.17%
Desflurane consumption in bt (1bt=240ml)	915,60	901	-14.60	-1.59%
Consumption of desflurane per operation in ml	69,848	64,742	-5,11	-7.31%
Batteries LR 14/2P	176	46	-130	-73.86%
Batteries 9V	139	0	-139	-100%
Set of Anesthesia Dept. warehouse stock items.	652	760	+108	+16.56%
Value of Anesthesia Dept. warehouse stock items.	###.###,##	###.###,##	-2.5806,70	-11.37%

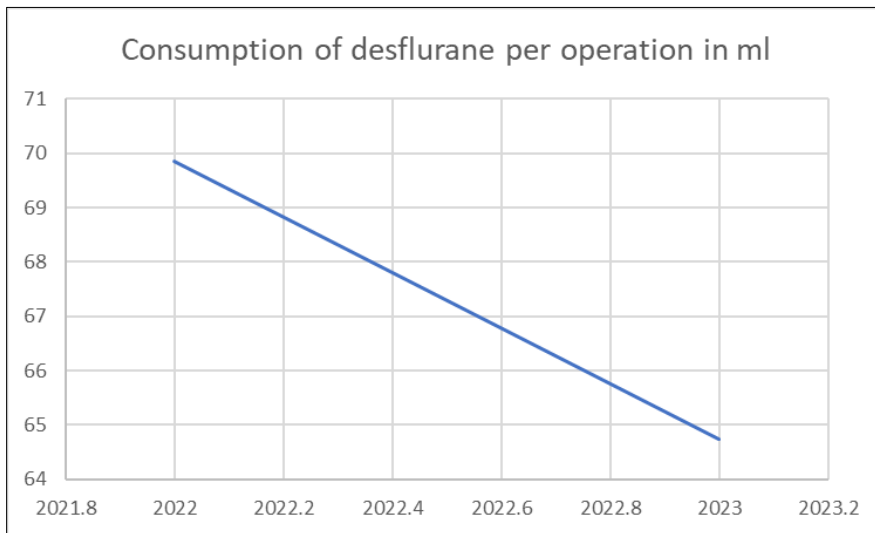
Below are the figures of the data in table 1:



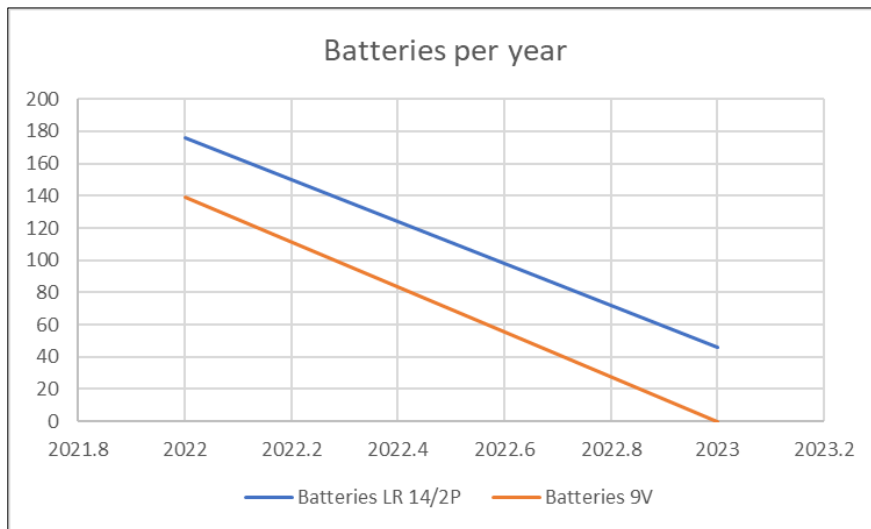
**Figure 1** Comparison of the total number of surgeries performed for the years 2022 and 2023.



**Figure 2** Comparative consumption of desflurane (in bt) for the years 2022 and 2023



**Figure 3** Comparative consumption of desflurane per surgery (in ml) for the years 2022 and 2023



**Figure 4** Comparison of the total amount of batteries used for the years 2022 and 2023.



**Figure 5** Comparing the number of the Department of Anesthesia warehouse stock items for the years 2022 and 2023

#### 4. Conclusion

With the adoption of the 5R program, it seems that financial and material resources are saved and the consumption of volatile gases per surgical operation has been significantly reduced.

#### Goals for 2025

- The glass packaging of medicines to be collected and recycled by specialized companies.
- To separate the recyclable materials by type (plastic, paper, glass, aluminum).
- To collect and oxidize the volatile anesthetic gases before they are released into the atmosphere.

#### Compliance with ethical standards

#### Acknowledgement

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#### Disclosure of conflict of interest

There is no Conflict of Interest for any of the authors: Maria S Chrysi, Georgios Georgiou, Olga Balaoura, Maria Bourazani.

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