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How green is my reusable bronchoscope?

Running head : Green House Gaz emissions of bronchoscopies.

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ABSTRACT

INTRODUCTION

Single-use bronchoscopes have replaced reusable ones in many institutions. This study aimed to evaluate the environmental and financial impacts of both strategies: reusable and single-use bronchoscopes.

MATERIAL AND METHODS

We conducted a pragmatic study in a 21-bed polyvalent ICU, in Saint-Brieuc, Bretagne, France. The eco-audit consisted of estimating greenhouse gas (GHG) emissions, considering the life cycle of each strategy. Greenhouse gas (GHG) emissions related to construction, packaging, transport and waste elimination were compared between 2 devices: the reusable bronchoscope, a Pentax® FI-16RBS that was disinfected twice daily; and the single-use bronchoscope, the bronchoflex agile® from TSC.

RESULTS

For the reusable bronchoscope, GHG emissions were marginally impacted by the number of bronchoscopies performed (from 185 kg eq.CO₂ per year to 192 kg eq.CO₂ for 10 or 110 bronchoscopies per year). For the reusable device, GHG emissions directly depended on the number of bronchoscopies performed with 3.82 kg eq.CO₂ emitted per bronchoscopy. The breakeven point for the reusable bronchoscope was estimated at 50 bronchoscopies in terms of GHG emissions and 96 bronchoscopies for financial considerations.

CONCLUSION

Considering current practice in our ICU, reusable bronchoscopes have lower GHG emissions when used more than 50 times a year and a lower cost when used more than 96 times a year as compared with single-use bronchoscopes.

Keywords : Life cycle assessment ; Bronchoscopy ; critical care ; global warming

INTRODUCTION

While climate change directly impacts the healthcare system, it brings healthcare workers on the front line [1]. In France, the health system produces 8% of the national greenhouse gas (GHG) emissions, with medical devices being incriminated for a fifth of them [2].

Consequently, physicians have to evaluate the environmental impact and the alternatives to currently used medical devices.

Among them, a flexible optical bronchoscope is a cornerstone of airway management in both operating room and intensive care units (ICU). Once, physicians mostly relied on reusable bronchoscopes but single-use bronchoscopes have been increasingly used in recent years. Some studies have been conducted to evaluate the environmental and financial impact of each solutions, with controversial results [3, 4]. We aimed to assess, through an eco-design approach, the environmental impact of both strategies in our ICU.

MATERIAL AND METHODS

We conducted a pragmatic, eco-audit study, in a 21-bed polyvalent ICU, in Saint-Brieuc, Bretagne, France. In our unit, bronchoscopies are performed by the intensivist physicians in charge of the patients. Since 2018, both techniques have been available 24 hours a day and 7 days a week. Reusable bronchoscopes were initially indicated to perform percutaneous tracheotomy. Then, with the emergence of COVID-19, it has been preferred for infected patients for infectious prevention reasons. Finally, both techniques were used unrestrictedly in other situations.

Eco-audit

The eco-audit consisted of estimating carbon impact considering the life cycle of the product, specifically GHG emissions, of each strategy. Data used for GHG emissions assessment were obtained from the website “Base empreinte” of the “Agence de la transition écologique” (<https://base-empreinte.ademe.fr>). Each step was taken into account including

- i) Production.
- ii) Packaging.
- iii) Transport.
- iv) Finally waste elimination was estimated using currently used disposal sectorisation.

The whole details are available in supplementary data and Supplementary Figure 1.

Reusable bronchoscope

The reusable bronchoscope was a Pentax FI-16RBS®. Standard disinfection was performed with Peracetic acid (Anios 1000®) and clear water rinsing. The protocol consisted of disinfection twice daily (bronchoscope operational immediately). A second scenario was then considered with disinfection once a week, but also before and after use (disinfection required before use). The full protocol is available in supplementary data.

The composition of the reusable bronchoscope was not available despite contact attempts with commercials. Destruction of a unit for the purpose of the study was considered disproportionate. Noteworthy, in other similar study, similar issues were reported and GHG emitted during the production process were either estimated or neglected [3, 4]. Consequently, GHG emitted during the production of the reusable bronchoscope could be calculated. The composition of the reusable bronchoscope was assumed to be similar with those of a single use bronchoscope, with respect for its higher weight. As the reusable bronchoscope weight corresponds to 3 times the weight of the single-use bronchoscope, GHG emission during the production of a single-use bronchoscope was multiplied by three to obtain the corresponding impact of the reusable one. As the expected lifespan was 8 years, GHG emissions due to the production phase were divided by the number of years of use to obtain annual GHG emissions.

Single-use bronchoscope

The single-use bronchoscope evaluated in the present analysis was the Bronchoflex agile® from TSC. Data regarding the exact composition and supply chain were obtained directly from the manufacturer. There was no disinfection procedure for the single-use bronchoscope. GHG emissions related to electronic components (camera with its printed cardboard) were included in the analysis. For the camera and the electronic component, the corresponding reference was obtained from the ADEME website either (site <https://base->

empreinte.ademe.fr/documentation/base-impact?idDocument=167). After use, the single-use bronchoscope was incinerated as dangerous health-care-associated waste.

Objectives

The primary aim of the study was to assess the GHG emissions related to a bronchoscopy in a French ICU when using a single use or a reusable bronchoscope. The secondary objective was the comparison of the price of each device.

RESULTS

In 2022, 110 bronchoscopies were performed in our ICU, 60 with a reusable bronchoscope and 50 with a single-use one.

The environmental and financial impact of reusable bronchoscopes are detailed in Table 1.

Yearly GHG emissions were only marginally impacted by the number of bronchoscopy performed (from 185 kg eq. CO₂ per year to 192 kg eq. CO₂ per year when 10 or 110 bronchoscopy are performed with the reusable bronchoscope, respectively) (Figure 1). The larger part of GHG emissions were related to the disinfection procedure (>95%) (Table 1).

Despite being produced and transported from European factories, transport was performed by trucks with a higher GHG emission factor than maritime transport. Price was estimated between 19 890.6€ (10 bronchoscopies performed a year) and 21 426€ (110 bronchoscopies performed a year) (Supplementary Figure 2), with 51% of the price related to human resources.

Data regarding the environmental and financial impact of the single-use bronchoscope and its composition, are reported in Table 2. GHG emissions directly depend on the number of bronchoscopy performed (Figure 1) with 3.82 kg eq. CO₂ emitted per bronchoscopy (418 kg eq. CO₂ emitted for 110 bronchoscopy performed with the single-use bronchoscope). The camera was estimated to be responsible for emissions of 1.25 kg eq. CO₂ per bronchoscopy, while printed board was estimated to be responsible for 0.26 kg eq. CO₂ (33% and 7% of the

total GHG emissions, respectively) (Supplementary Figure 2). Price was 220.2€ per bronchoscopy. Considering the functional unit of the study (bronchoscopy activity during 2022 in our ICU), GHG emission related to bronchoscopy was estimated at 298 kg eq. CO₂ for the 110 bronchoscopies performed.

The break-even point of reusable bronchoscopes was estimated at 50 bronchoscopies for GHG emissions and 96 bronchoscopies for financial considerations. When considering an alternative scenario (disinfection once a week but also before and after each use), breakeven points were reduced to 28 bronchoscopies for GHG emissions and 50 bronchoscopies for financial considerations.

DISCUSSION

In this pragmatic study, we evaluated the environmental and financial impact of single-use as compared with a reusable bronchoscope. We observed that GHG emissions were lower with reusable bronchoscopes when used at least 50 times per year, and a lower cost when used at least 96 times per year.

Our results are in line with those of Bringier *et al.* [3] who estimated the impact of 200 bronchoscopies performed during a year in their operating room. They calculated that using only single-use bronchoscopes would be responsible for 7 800 kg eq.CO₂ GHG emission while using only reusable bronchoscopes would emit 5 900 kg eq.CO₂. Disinfection is the key step as its improvement would have the biggest impact on GHG emissions and cost. Herein, disinfection supplies correspond to 95% of the GHG emissions of the reusable bronchoscope. GHG emission decreased with the number of bronchoscopes handled per cleaning procedure [4]. Regarding financial impact, Perbet *et al.* also reported a lower cost of single-use bronchoscopes when more than 55 bronchoscopies are performed each year [5].

Regarding the quality of care, data are conflictual. In some studies, physicians tended to be more satisfied with the single use bronchoscope while in others, performance were considered

similar or even higher with the reusable one [3, 5]. We did not evaluate the quality of the bronchoscopy nor the risk of infectious cross-transmission with both types of bronchoscopes. However, there were no major adverse events related to bronchoscopy during study period with any of the devices.

Our eco-audit is the first conducted in an ICU. Noteworthy, our unit have a similar size with most French ICUs and therefore corresponds to a common situation in our area. Finally, if breakeven for financial consideration is often available, breakeven of environmental consideration needs to be further evaluated.

However, we may acknowledge some limitations. First, data presented correspond to an eco-audit in a specific place during a specific period of time and results may not be transposable, even though similar results are expected in nearby areas. Second, life cycle assessment only take into account measurable parameters available in the database. Consequently, as GHG emissions were obtained from the ADEME database, respective emissions correspond to generic emissions of corresponding chemical products. Moreover, GHG emitted during the production of reusable bronchoscopes could not be calculated precisely. However, it is only produced once for an expected lifespan of 8 years, so the importance of the Pentax production phase is relatively small. Finally, we only evaluated the impact of the bronchoscopy strategy on GHG emissions but not on other environmental threats.

In conclusion, considering current practice in our ICU, we evaluated that reusable bronchoscopes have lower GHG emissions when used more than 50 times a year and a lower cost when used more than 96 times a year, as compared with single-use bronchoscopes. As global warming needs emergent action, physicians should evaluate alternatives for products with high GHG emissions, such as those used in large quantities or those with particularly high GHG emission factors.

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Figure 1. Green House gas emission of each strategy.

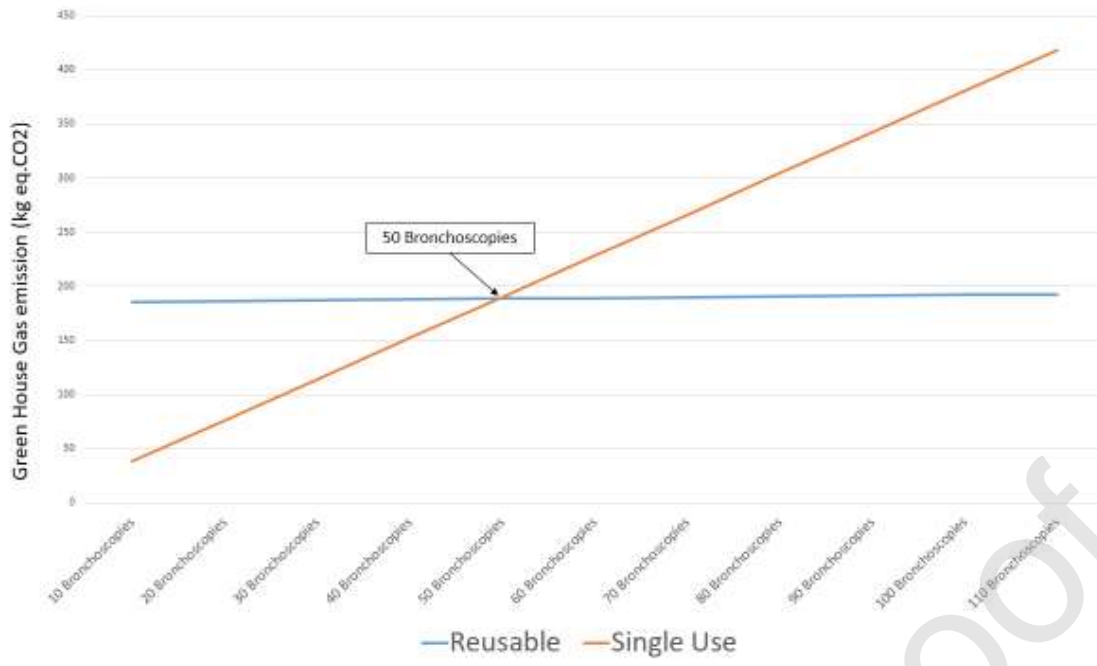


Table 1. Environmental and financial impact of reusable bronchoscope in our ICU, per year.

		Quantity per unit	Number of unit per year	GHG (kg eq.CO2)	Price (€)
Acquisition		360 g	1	1.31*	1 085*
Maintenance		1	-	-	1 900
Disinfection					
Septopredis	Didecyldimethylammonium chloride	1000 mL			
	Packaging High density Polyethylene	92 g			
	Truck	1200 km	2.61 L	0.91	72.6
	Waste water				
Anios 1000	Peracetic Acid	1000 mL			
	Packaging High density Polyethylene	92 g			
	Truck	1 200 km	6 257 L	84.7	5965.7
	Waste water				
Gowns	High density Polyethylene	6 g			
	Packaging High density Polyethylene	30 g			
	Boat	20 000 km	1 460 units	15.5	470.4
	Standard waste				
Gloves	Polychlorure Vinyl	3 g			
	Boat	9 900 km	2 920 units	12.9	89.0
	Standard waste				
Syringes	Polypropylene	12.5 g			
	Isopren	1.4 g			
	Packaging - polyamide	1 g	1 460 units	58.8	54.2
	Truck	1250 km			
	Standard waste				
Facial shield	Polypropylene	2 g			
	Alumium	0.45 g			
	Packaging - Carton	100 g	730 units	11.4	54.9
	Truck	1 250 km			
	Standard waste				
Human resources			365 hours		10198.8
Total				185.5	19 890.6

Note. GHG : Green house Gas. * As expected life span was assume to be 8 years, the price of acquisition and the GHG emission of production step where divided by the expected number of year of use.

Table 2. Environmental and financial impact of single use bronchoscope in our ICU, per unit.

	Quantity per unit	GHG (kg eq.CO2/unit)	Price (€)
Material			
	Nitrile butadiene	61.5 g	0.33
	Polyformaldehyde	5.4 g	0.01
	Polypropylene/polyamide	5.4 g	0.04
	Silicon	5.6 g	0.02
	Polyvinyl chloride in electric cable	2 meters	0.76
	Conductor in electric cable	2 meters	0.04
	Other metals	7.7 g	0.02
Electronic			220
	Camera - industrial sensor	1	1.25
	Printed card board	2.73 cm ²	0.26
Packaging			
	Container - polyethylene	160 g	0.54
	Plastic packaging - polyethylene	40 g	0.14
Transport			
	Truck	1 300 km	0.10
Waste Elimination			
	Hazardous waste	328 g	0.31
Total			3.82
			220.2

Note. GHG : Green house Gas.