

The way to sustainable healthcare:  
**Reduction of CO<sub>2</sub> emissions  
and turnaround time  
through innovative  
disinfection methods.**

A quantitative study with  
Reinier de Graaf Hospital and TU Delft





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# Introduction

The Healthcare sector is responsible for significant CO<sub>2</sub> emissions. Several publications have shown the healthcare sector are responsible for 5 percent of total CO<sub>2</sub> emissions worldwide (World Bank, 2017). In the United States, this percentage has increased to as much as 9 percent (Eckelman, 2016), while in the UK it is 6.3 percent (NHS and Public Health England, 2018) and in the Netherlands the sector produces 7 percent (RIVM, 2022).

The source of these CO<sub>2</sub> emissions is diverse and can be attributed to various processes within healthcare, such as energy consumption, production, transport and the use of goods. These emissions, generated by necessary processes themselves, contribute to climate change. The effects of climate change are felt in the form of temperature changes, drought, extreme weather events and floods. Studies show that climate change has negative effects on public health (Cianconi et al., 2020; Eckelman, 2018). This poses a paradox because, by contributing to CO<sub>2</sub> emissions and climate change, healthcare directly contributes to the negative impacts of climate change on public health.

***“The effects of climate change are felt in the form of temperature changes, drought, extreme weather events and floods.”***



It is well known that an operating room has high energy consumption and generates a lot of waste (MacNeill, 2017; Jansen et al., 2020). In addition, disinfection and cleaning processes within the hospital also contribute significantly to overall CO<sub>2</sub> emissions (Namburar et al., 2021; Ofstead et al., 2017). For example, each endoscopy results in an average of 5.51 pounds (Namburar et al., 2021). Reducing the large footprint of the medical sector requires a major transition in healthcare. In the COP2 UN climate conference, a group of 50 countries have committed to this ambition (WHO, 2021). To achieve this goal, impactful and feasible measures need to be taken by the entire sector. There is no single solution to this problem, but several measures must be taken.

Research by the Social and Economic Council (SER) shows that one in seven workers in the Netherlands currently works in the healthcare sector. If the demand for healthcare continues to grow, it is expected that by 2040, one in four workers will have to work in the sector (SER, 2020). However, the growing demand for healthcare also creates a rising workload including at the Central Sterilisation Department (CSD) and Central Scopes Cleaning and Disinfection department. For example, the Reinier de Graaf Hospital (RDGG) in the Netherlands (2023) indicates that more and more ENT endoscopies are performed at their facilities. These endoscopies are not scheduled in the same way as in Gastrointestinal (GI) departments, and this makes it difficult for the CSD to respond or plan for flexible channel-less ENT scope reprocessing. At the same time, it is also increasingly difficult to find staff in these departments (NOS, 2022). It is therefore of great importance to look for solutions that reduce the workload.





The RDGG currently applies washing machines for disinfecting ENT scopes, namely Cantel's Medivator Advantage Plus Pass Thru. This process takes 40 minutes (Reinier de Graaf, 2023). Using this machine results in the consumption of 7,93 gallons of water, 20,09 fluid ounces of chemicals and 1800 watts of power per two flexible channel-less ENT scopes. Moreover, the RDGG has an ambulatory ENT clinic where flexible channel-less ENT scopes are also used. Since there is no possibility for disinfection at this location, the flexible channel-less ENT scopes are transported twice a day by vans to the RDGG's CSD, with each trip taking 17 minutes (RDGG, 2023).

***“UV Smart (Rijswijk, Netherlands) has developed a disinfection device, the UV Smart D60, which can disinfect Flexible channel-less ENT scopes in 60 seconds.”***

UV Smart (Rijswijk, Netherlands) has developed a disinfection device, the UV Smart D60, which can disinfect flexible channel-less ENT scopes in 60 seconds. It applies UV technology as a disinfection method, using only 650 watts and no consumption of chemicals or water. Thanks to this innovation, disinfection can be performed in the department or clinic, eliminating the need for transport. In Rudhart et al (2021) study, the UV Smart D60 was shown to be an

effective method for disinfection. Biadsee et al (2023) also proved that disinfection with the UV Smart D60 is more cost-effective compared to other methods. At “high-volume clinics”, where an average of 2592 flexible channel-less ENT scopes are disinfected per year, the reprocessing costs per patient are \$38.52 for Cidex-OPA, \$26.42 for Revital-Ox, \$30.48 for Tristel Trio Wipes, and \$22.70 for UV Smart D60, respectively. However, it has not yet been proven that the UV Smart D60 is also a more environmentally friendly solution.

The aim of this study was to conduct an analysis between the current disinfection method in the RDGG (Automatic Endoscope Reprocessor) and the new disinfection method with the UV Smart D60 based on time and CO<sub>2</sub> reduction. This will allow us to outline the environmental impact of the different methods. The intention of this study is that hospitals in the future will have transparent guidance when choosing a sustainable, cost-effective and time-effective disinfection method.





# Method

**This analysis compared the current disinfection method (AER) of flexible chanel-less ENT scopes in RDGG with the new solution, the UV Smart D60, focusing on the differences in time and CO<sub>2</sub> emissions. Both methods are CE certified in Europe under the MDR, and are therefore allowed to disinfect flexible channel-less ENT scopes. In addition, both methods are proven to be effective (Rudhart, 2021; Halmans, 2022). The UV Smart D60 is already successfully used in numerous hospitals in Spain, the Netherlands, Belgium, England and France. Therefore, we do not discuss the efficacy further in this study.**

**The current process at the CSD of the RDGG goes as follows, looking at a flexible channel-less ENT scope going from dirty to clean we follow 8 steps:**

1. An endoscopy is performed on a patient;
2. The flexible channel-less ENT scope is cleaned immediately after the consultation;
3. The flexible channel-less ENT scope is placed in a container;
4. After the morning consultation, these flexible channel-less ENT scopes are transported (internally or via a van) from the outpatient clinic to the CSD;
5. A short pre-cleaning is performed on the CSD;
6. The flexible channel-less ENT scope is then placed in the Medivator Advantage Plus Pass Thru for 40 minutes.
7. Drying/preparing for transport.
8. After disinfection, the flexible channel-less ENT scope can be transported back to the outpatient clinic; internally or via a van.

The future process at RDGG with the UV Smart D60 is as follows, looking at a flexible channel-less ENT scope that goes from dirty to clean, we follow just 6 steps:

1. An endoscopy is performed on a patient;
2. The flexible channel-less ENT scope is cleaned immediately after the consultation;
3. The flexible channel-less ENT scope is placed in a container and taken to the room where the UV Smart D60 is located;
4. Manual pre-cleaning of the flexible channel-less ENT scopes is done with a damp microfiber cloth;
5. The flexible channel-less ENT scope is then exposed to UV technology for 60 seconds;
6. After the disinfection cycle, the flexible channel-less ENT scope can either be used immediately or transported back to the patient’s room.

Through a quantitative study at the RDGG, data were collected regarding disinfection of flexible channel-less ENT scopes. We compared the following elements of the two methods, independently retrieving data; transport, turnaround time, consumption of chemicals, water and energy. These elements are described below.

**Table 1**  
Overview of identified endoscopies and trips per year in Ambulatory Clinic and main RDGG location

	Number at ambulatory clinic	Ambulatory clinic per year	Number main location	Main location per year
Endoscopies per week	38	1.596	87	3654
Number of weeks active on site	x	42 weeks	x	42 weeks
Number of bus trips per week	6	252 trips	x	x
Number of minutes per trip	17 minutes	4.284 minutes	x	x
Number of miles per trip	6.4 miles	1723 miles	x	x



» **2.1 Transport**

Transport goes between the ambulatory clinic and the RDGG’s main location. For this transport, the RDGG uses a Mercedes-Benz Sprinter (RDGG, 2023). This bus consumes 0.25 pounds of CO<sub>2</sub> per miles (Cars-data.com). The distance between the two locations is 6.84 miles and it takes 17 minutes. Several consultation hours are held weekly at Ambulatory Clinic location, and therefore 6 trips per week are needed (Table 1).

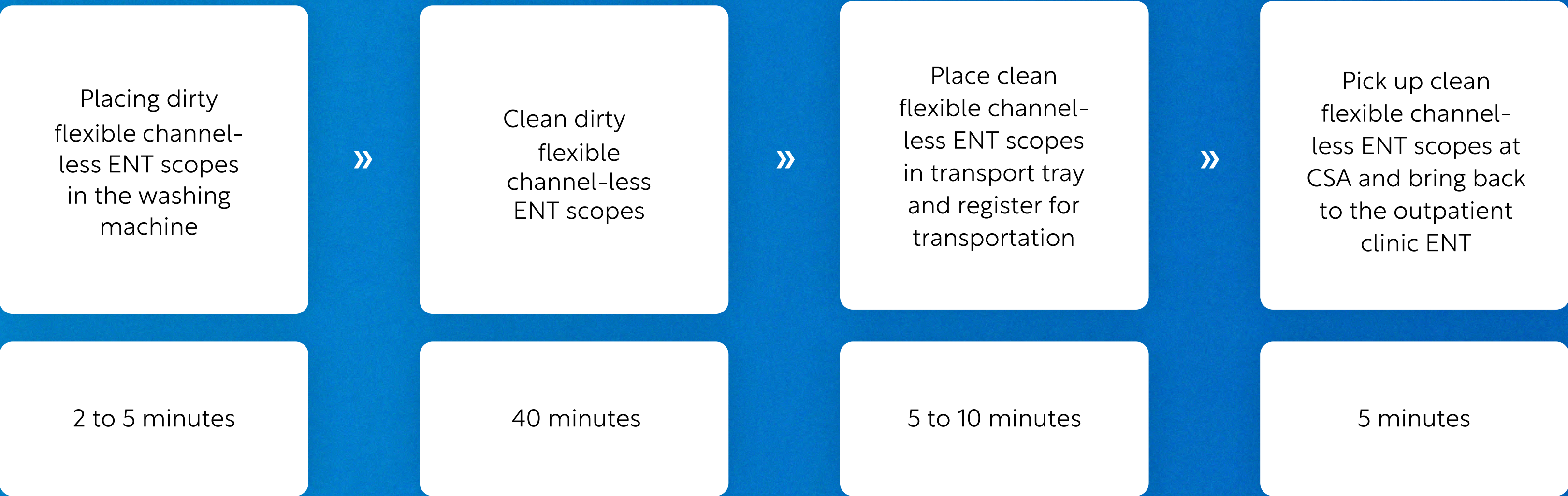
» **2.2 Consumption of chemicals, water, and energy**

Disinfection with a AER requires consumption of chemicals, water and energy. Table 2 compares the consumption of the AER with that of the UV Smart D60. For the current method with the AER, consumption at the main location and the Ambulatory Clinic location are taken into account. The difference is that disinfection at the main site does not require transport. Research by research bureau Pré shows that 0.26 gallons of tap water emits 0.7 pounds of CO<sub>2</sub> (2005). A commonly used chemical for laundry disinfection in the medical world is Isopropyl alcohol (IPA). According to the United States Environmental Protection Agency (EPA), producing 1.73 pounds of IPA can result in about 7.94 pounds of CO<sub>2</sub>. 0.26 gallon of IPA weighs about 6.57 pounds, meaning the CO<sub>2</sub> emissions associated with the production of 0.26 gallon of IPA is about 6.17 pounds of CO<sub>2</sub> (Liew, 2022). Furthermore, research by klimaatplein shows that 1 Kilowatt hour emits 1.01 pounds of CO<sub>2</sub> (klimaatplein.nl).

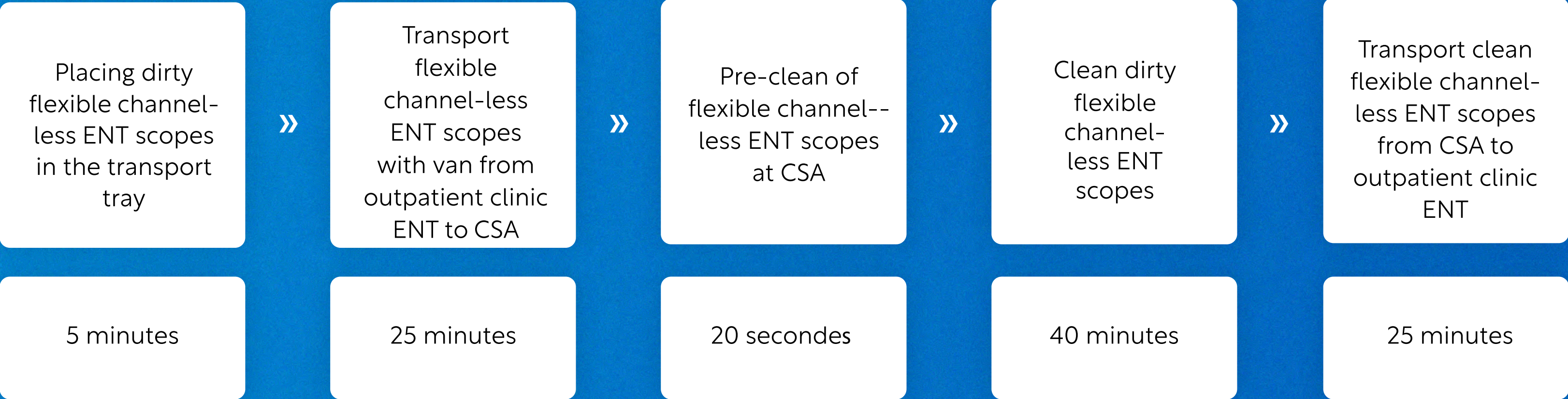
» **2.3 Turnaround time**

In this Whitepaper, the term flexible channel-less ENT scope turnaround time’ refers to the time it takes to fully clean and disinfect a flexible channel-less ENT scope so that it is reliable and suitable for reuse. In other words, it indicates how quickly a flexible channel-less ENT scope is available again for use on the next patient. There are two different types of processes here; process at the Ambulatory Clinic and process Main location. The ambulatory clinic requires transport of the flexible channel-less ENT scopes to the main site to perform disinfection. The process at the main site only requires transport within the hospital. Figure 1 shows this turnaround time. Figure 2 shows the turnaround time of the RDGG at the ambulatory clinic.

**Figure 1**  
Turnaround time RDGG main location (RDGG, 2023)



**Figure 2**  
Turnaround time RDGG ambulatory clinic (RDGG, 2023)





# Results

This chapter compares disinfection with the AER and UV Smart D60 at the ambulatory setting. This study looked at several factors, including the use of transport, and consumption of chemicals, water and energy, CO<sub>2</sub> emissions and the turnaround time of flexible channel-less ENT scopes.

## 3.1 Transport

At the RDGG ambulatory clinic, 38 endoscopies per week are performed. For disinfection of these flexible channel-less ENT scopes, they drive back and forth between ambulatory clinic and the main location 6 times a week. This location operates 42 weeks per year in the ENT department (see table 1). This is 252 trips of 17 minutes per year (table 1). Table 2 shows that 1723 miles per year are driven for disinfection of these ENT scopes, emitting 1129 pounds of CO<sub>2</sub> per year. The method used at the main site does not require transport by bus, so there are no CO<sub>2</sub> emissions with this method of transport.

With the UV Smart D60, no mile are driven either, which also results in no CO<sub>2</sub> emissions from transport.

“At the RDGG ambulatory clinic, 38 endoscopies per week are performed.”

Table 2

Usage water, chemicals, energy and CO<sub>2</sub>.

AER	Per flexible 2 ENT scopes	1596 flexible ENT scopes ambulatory clinic	3654 endoscopies main location
Chemicals 2.8 kg CO <sub>2</sub> / liter	600 ml 1.68 kg CO <sub>2</sub> per 600 ml	478.8L 1340 kg CO <sub>2</sub>	1096 liter 3069 kg CO <sub>2</sub>
Water 0.3 kg CO <sub>2</sub> / liter	3 liter 0.9 kg CO <sub>2</sub>	2394L 718 kg CO <sub>2</sub>	5481L 2466.4 kg CO <sub>2</sub>
Energy consumption	1800 watt 1.8 kwh 0.82 kg CO <sub>2</sub>	1436.400 Watt 1436 Kwh 654,82 kg CO <sub>2</sub>	3.288.600 Watt 3288 Kwh 1499.3 kg CO <sub>2</sub>
Kilometers driven 0.185 kg CO <sub>2</sub>	11 kilometer 2,035 kg CO <sub>2</sub> per 11 km	2772 kilometers 512 kg CO <sub>2</sub>	0 kilometers 0 kg CO <sub>2</sub>
Total Co <sub>2</sub>	9.77 lbs CO <sub>2</sub>	7,111.7 lbs CO <sub>2</sub>	15,5073.3 lbs CO <sub>2</sub>

D60	Per 2 flexible ENT scopes	1596 flexible ENT scopes total	3654 endoscopies main location
Chemicals 2,8 kg CO <sub>2</sub> / liter	0 0 kg CO <sub>2</sub>	0L 0 kg CO <sub>2</sub>	0L 0 kg CO <sub>2</sub>
Water 0.3 kg CO <sub>2</sub> / liter	0 0 kg CO <sub>2</sub>	0L 0 gram CO <sub>2</sub>	0L 0 kg CO <sub>2</sub>
Energy consumption	1300 watt 0.59 CO <sub>2</sub>	1,037,400 watt 1,037,2 Kwh 472,87 kg CO <sub>2</sub>	2375100 2,375,1 Kwh 1083 kg CO <sub>2</sub>
Kilometers driven 0.185 kg CO <sub>2</sub>	0 kilometer 0 kg CO <sub>2</sub>	0 kilometer 0 kg CO <sub>2</sub>	0 kilometer 0 kg CO <sub>2</sub>
Total CO <sub>2</sub>	1.3 lbs CO <sub>2</sub>	1,042.2 lbs CO <sub>2</sub>	2,388.3 lbs CO <sub>2</sub>



Table 3

Comparison time of disinfection with the 6: G and the UV Smart D60.

Fase	6: G	Time in minutes	UV Smart D60	Time in minutes
1	Endoscopy is performed on a patient;	x	Endoscopy is performed on a patient;	x
2	I ] Z [āZmWZ'X] VccZā'āZh': Cl' hXdeZ'`h' eg" XāVcZY'`b`b ZY'ViZanV[iZg' Xdchj āVi`dcO	1 minute	I ] Z [āZmWZ'X] VccZā'āZh': Cl' hXdeZ'`h' eg" XāVcZY'`b`b ZY'ViZanV[iZg' Xdchj āVi`dcO	1 minute
3	I ] Z [āZmWZ'X] VccZā'āZh': Cl' hXdeZ'`h' eā/XZY'`c' igVchedg' igVn'VcY'ādX' ZY'VcY' XdāXiZY [dgi gVchedgVi`dcO	5 minutes	The flexible ENT scope is placed in a container and brought to the room where the UV Smart D60 is located	5 minutes
4	In the afternoon, after morning consultation hours, these flexible channel-less ENT scopes are transported by bus from the outpatient clinic to CSA;	25 minutes		
5	At the CSA, a brief pre-cleaning session follows;	20 seconds	Here follows manual pre-cleaning of the flexible channel-less ENT scopes with a damp microfiber cloth (with water) for 20 seconds;	20 seconds
6	Then the flexible channel-less ENT scope is placed in the Medicator Advantage Plus Pass Thru for 40 minutes	40 minutes	The flexible channel-less ENT scope is then exposed to the UV technology for 60 seconds while suspended (Rudhart, 2021);	1 minute
7	After disinfection, the flexible channel-less ENT scope is placed in transport container, locked and transported back to the outpatient clinic.	25 minutes	After the disinfection cycle, the flexible channel-less ENT scope can either be used immediately or transported back to the patient room.	5 minutes
Total with the AER		96 minutes	Total with the UV Smart D60	12 minutes

» 3.2 Chemicals, water and energy

Research shows that disinfection with the AER in the RDGG consumes 126.5 gallons of chemicals per year and 2,952 pounds of CO<sub>2</sub> for disinfection of flexible channel-less ENT scopes at the ambulatory clinic, in addition it consumes 289.7 gallons of chemicals and 6,761 pounds of CO2 for the Main Location. The UV Smart D60 consumes 0 gallon of chemicals and 0 pound of CO<sub>2</sub> per year for disinfection of flexible channel-less ENT scopes at the ambulatory clinic (table 2).

In addition, the study shows that the AER for the ambulatory clinic consumes 700.7 gallons of water per year and 1,582 pounds of CO<sub>2</sub>, for Main location the AER consumes 1,447.6 gallons of water and 5,434 pounds of CO<sub>2</sub>, the UV Smart D60 consumes 0 gallon of water and 0 pounds of CO<sub>2</sub> for disinfection of flexible channel-less ENT scopes.

Furthermore, for the ambulatory clinic, the AER consumes 1,436,400 watts and 3,167 pounds of CO<sub>2</sub> per year, for main location 3,288,600 and 3,303 lbs CO<sub>2</sub>, and the UV Smart D60 3,412,500 watts and 1,042 lbs CO<sub>2</sub> per year.

3.3 Turnaround time

Table 3 shows the turnaround time at the RDGG from the ambulatory clinic to the main location. Here you can see that the turnaround time of a flexible channel-less ENT scope with the AER is 96 minutes, and the turnaround time with the UV Smart D60 is 12 minutes. In addition, Figure 1 shows that the turnaround time at the main location is 60 minutes.



# Discussion

CO<sub>2</sub> emissions from health care are significant. Several processes within healthcare contribute to these CO<sub>2</sub> emissions. In addition, it appears that the demand for care is ever-increasing, which means that the workload within healthcare is also growing. It is therefore important to reduce the workload and CO<sub>2</sub> emissions. In the results, we analysed the consumption and turnaround time of the current disinfection method in the RDGG alongside the consumption and turnaround time of the UV Smart D60.

» **4.1 Chemicals, water and energy and transport**

The analysis in this study shows that the current disinfection method with the washing machine requires a lot of water, chemicals, and energy consumption. Table 4 shows that by purchasing the D60, 408.8 gallons of chemicals, 2,080 gallons of water , 3686.8 KWh of energy, and 1,723 miles of transportation can be saved annually. If you convert this to CO<sub>2</sub> emissions, as shown in table 5, you can see that by purchasing the D60, 19,180 pounds of CO<sub>2</sub> emissions can be saved per year. For example, this could power the Eiffel Tower for 119 days (Ecotree.nl).

**“Table 4 shows that by purchasing the D60, 408.8 gallons of chemicals 2,080 gallons of water, 3686.8 KWh of energy, and 1,723 miles of transportation can be saved annually. If you convert this to CO<sub>2</sub> emissions, as shown in table 5, you can see that by purchasing the D60, 19,180 pounds of CO<sub>2</sub> emissions can be saved per year”**

**Table 4**  
Savings per year

Per year	Ambulatory clinic	Main location	D60	Savings
Chemicals	478,8 liters	1.069 liters	0	408,8 gallons
Water	2394 liters	5.481 liters	0	2,080 gallons
Energy consumption	1436 KWh	3288 KWh	1037,2 KWh	3686,8 KWh
Kilometers	2772 kilometers	0	0	1,723 miles

**Tabel 5**  
CO<sub>2</sub> savings per year

Per year	Ambulatory Clinic	Main location	UV Smart D60	Total savings AER versus UV Smart D60
Chemicals	1340 kg CO <sub>2</sub>	3069 kg CO <sub>2</sub>	0 kg CO <sub>2</sub>	9,917 lbs CO <sub>2</sub>
Water	718 kg CO <sub>2</sub>	2466.4 kg CO <sub>2</sub>	0 kg CO <sub>2</sub>	7,022 lbs CO <sub>2</sub>
Energy consumption	654,82 kg CO <sub>2</sub>	1499.3 kg CO <sub>2</sub>	1555,87 kg CO <sub>2</sub>	51,916 lbs CO <sub>2</sub>
Kilometers	512 kg CO <sub>2</sub>	0 kg CO <sub>2</sub>	0 kg CO <sub>2</sub>	1,129 lbs CO <sub>2</sub>
Total savings AER versus UV Smart D60				19,190 lbs CO <sub>2</sub>



» **4.2 Turnaround time**

The analysis in this study shows that the current disinfection method with the washing machine takes a lot of time. For example, Table 3 shows that the turnaround time for flexible channel-less ENT scopes at the main location is 96 minutes, whereas at the main location, it takes 60 minutes. In comparison, the D60 takes only 12 minutes for the turnaround time, as shown in Table 3. Table 6 shows that significant time can be saved for various employees if disinfection is performed using the D60. If a UV Smart D60 is used for disinfection of flexible channel-less ENT scopes at the main location, 2.5 FTE per year can be saved.

***“If a UV Smart D60 is used for disinfection of flexible channel-less ENT scopes at the main location, 2.5 FTE per year can be saved.”***



**Table 6**  
Savings in hours per year

	Ambulatory Clinic	Main location
Turnaround time of 1 flexible channel-less ENT scope	96 minutes	60 minutes
Saving in minutes compared to one UV Smart D60	86 minutes	48 minutes
Number of disinfections per year	1596 endoscopies	3654 endoscopies
Total hour savings when disinfection with UV Smart D60	137.256 minutes = 2.287,6 hours	175.396 minutes = 2.923 hours





This CO<sub>2</sub> reduction analysis has shown that disinfection of flexible channel-less ENT scopes with the UV Smart D60 is the most sustainable and time-efficient method. When interpreting the results, it should be kept in mind that using the UV Smart D60 for disinfection shifts the process from Central Sterilization to Decentralized Sterilization. This shift has benefits, such as less transportation and shorter turnaround times. However, it can also have drawbacks, such as more work for nurses in the ENT department and no supervision of the pre-cleaning process. Although this may result in more work for staff, research also shows that it ultimately saves work because patients no longer need follow-up appointments since flexible channel-less ENT scopes are always available on site (ETZ, 2022). Additionally, research (ETZ, 2022) shows that doctors perform more endoscopies with the arrival of the UV Smart D60 since they always have a flexible channel-less ENT scope at their disposal. This ultimately leads to better diagnosis.

***“With the UV Smart D60, flexible channel-less ENT scopes can be disinfected on-site, reducing the need for transportation.”***

Currently, flexible channel-less ENT scopes are often transported to other locations for disinfection. This carries the risk of damage to flexible channel-less ENT scopes, which can lead to higher repair and replacement costs and potentially loss of use time. With the UV Smart D60, flexible channel-less ENT scopes can be disinfected on-site, reducing the need for transportation. This can lead to a reduction in flexible channel-less ENT scope damage as a result of transportation, which is a cost-effective and sustainable approach.

Our analysis focused on comparing the UV Smart D60 to the Medivators Advantage Plus pass-thru Automatic Endoscope Reprocessor (AER) by Cantel. However, there are other disinfection washers from brands such as Wassenburg and Olympus, and there are alternative methods for disinfection of flexible channel-less ENT scopes such as Tristel Trio Wipes and Cidex OPA. These were not examined in this study. Although the UV Smart D60 is approved under the current European MDR legislation, some guidelines regarding flexible channel-less ENT scope disinfection are outdated. In the Netherlands, UV technology disinfection is included in the Steering Group for flexible Scope Cleaning and Disinfection (SFERD, 2022). However, UV technology is not always included in national regulations in other countries. Therefore, implementing this innovative method requires a change in guidelines, and pragmatic handling of these regulations is advised for infection control & reprocessing specialist.

Another limitation of our study is that we only considered the use of the RDGG ambulatory clinic. Not every hospital has this logistical challenge, and transport emissions may not always be considered in decision-making. Future research could focus on examining this method in different hospitals. This study is based on quantitative data from a single hospital, and a follow-up study could investigate this method at multiple hospitals.



# Conclusion

Through a CO<sub>2</sub>-reduction analysis, two methods for disinfecting flexible channel-less ENT scopes have been evaluated. The UV technology from UV Smart offers a sustainable and time-efficient solution for the Reinier de Graaf Gasthuis hospital. With the increasing demand for healthcare and the climate crisis in mind, the UV Smart D60 can be a good first step towards the right direction.





This whitepaper was jointly developed with UV Smart technologies B.V.

CONFLICT OF INTEREST:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This research was developed with help & technical input from UV Smart Technologies B.V.

The UV Smart D60 is pending FDA clearance

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