The way to sustainable healthcare:

# Reduction of $CO_2$ emissions and turnaround time through innovative disinfection methods.

A quantitative study with
Reinier de Graaf Hospital and TU Delft

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# Content



# Introduction

**The Healthcare sector is responsible for significant $CO_2$ emissions. Several publications have shown the healthcare sector is responsible for 5 percent of total $CO_2$ 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 $CO_2$ 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 $CO_2$ 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 $CO_2$ emissions (Namburar et al., 2021; Ofstead et al., 2017). For example, each endoscopy results in an average of 2.4 kg of waste (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.

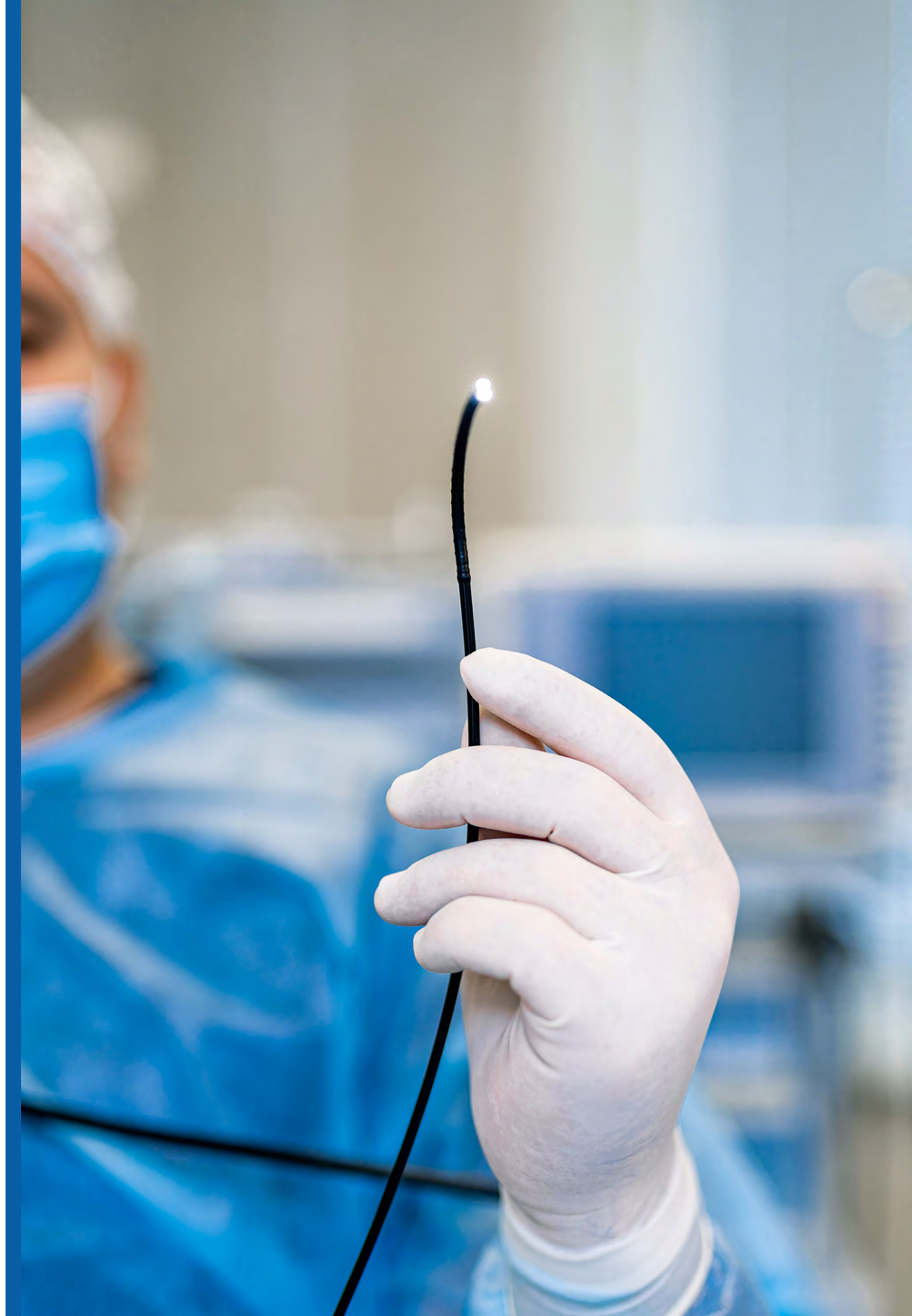
Research by the Social and Economic Council (SER) shows that one in seven workers in the Netherlands currently works in the healthcare sector. If the demand for healthcare continues to grow, it is expected that by 2040, one in four workers will have to work in the sector (SER, 2020). However, the growing demand for healthcare also creates a rising workload including at the Central Sterilisation Department (CSD) and Central Endoscopes 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 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 endoscopes, 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 30 litres of water, 600 millilitres of chemicals and 1800 watts of power per two endoscopes. Moreover, the RDGG has an ambulatory ENT clinic where endoscopes are also used. Since there is no possibility for disinfection at this location, the endoscopes 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 endoscopes in 60 seconds."***

UV Smart (Rijswijk, Netherlands) has developed a disinfection device, the UV Smart D60, which can disinfect flexible channel-less endoscopes in 60 seconds. It applies UV-C light 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 endoscopes are disinfected per year, the reprocessing costs per patient are €35.64 for Cidex-OPA, €24.45 for Revital-Ox, €28.20 for Tristel Trio Wipes, and €21.00 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 (Washer on CSD) and the new disinfection method with the UV Smart D60 based on time and $CO_2$ 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 (WD) of flexible channel-less endoscopes in RDGG with the new solution, the UV Smart D60, focusing on the differences in time and $CO_2$ emissions. Both methods are CE certified in Europe under the MDR, and are therefore allowed to disinfect endoscopes. 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 an endoscope going from dirty to clean we follow 8 steps:

1. An endoscopy is performed on a patient;
2. The endoscope is cleaned immediately after the consultation;
3. The endoscope is placed in a container;
4. After the morning consultation, these endoscopes 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 endoscope is then placed in the Medivator Advantage Plus Pass Thru for 40 minutes.
7. Drying/preparing for transport.
8. After disinfection, the endoscope 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 an endoscope that goes from dirty to clean, we follow just 6 steps:

1. An endoscopy is performed on a patient;
2. The endoscope is cleaned immediately after the consultation;
3. The endoscope 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-free endoscopes is done with a damp microfiber cloth;
5. The endoscope is then exposed to UV-C light for 60 seconds;
6. After the disinfection cycle, the endoscope 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 endoscopes. 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 kilometers per trip** | 11 kilometers | 2772 kilometers | 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 185 grams of $CO_2$ per km (Cars-data.com). The distance between the two locations is 11 kilometres 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 the WD requires consumption of chemicals, water and energy. Table 2 compares the consumption of the WD with that of the UV Smart D60. For the current method with the WD, 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 1 litre of tap water emits 0.3 kg $CO_2$ (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 one kilogram of IPA can result in about 3.6 kilograms of $CO_2$. One litre of IPA weighs about 0.785 kilograms, meaning the $CO_2$ emissions associated with the production of one litre of IPA is about 2.8 kilograms of $CO_2$ (Liew, 2022). Furthermore, research by klimaatplein shows that 1 Kilowatt hour emits 0.46 KG of $CO_2$ (klimaatplein.nl).

## 2.3 Turnaround time

In this Whitepaper, the term 'endoscope turnaround time' refers to the time it takes to fully clean and disinfect an endoscope so that it is safe and suitable for reuse. In other words, it indicates how quickly an endoscope 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 endoscopes 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)

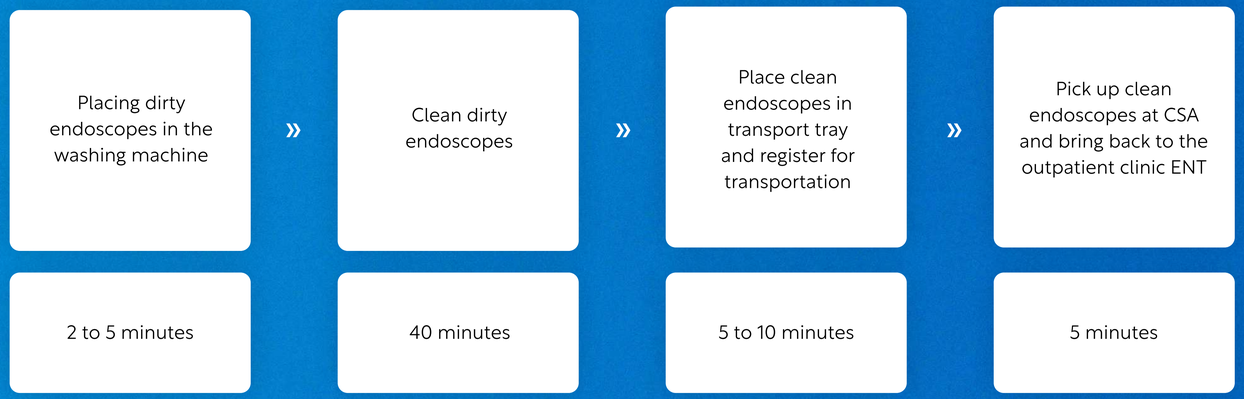
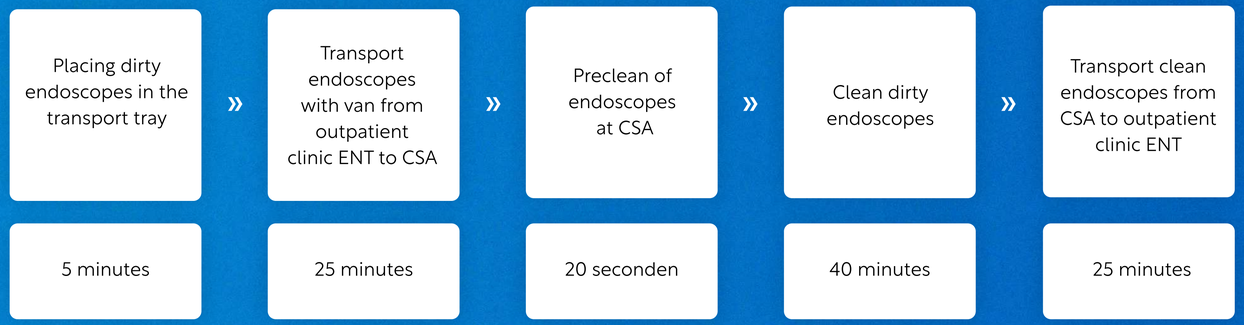



**Figure 2**

Turnaround time RDGG ambulatory clinic (RDGG, 2023)



# Results

**This chapter compares disinfection with the WD 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, $CO_2$ emissions and the turnaround time of endoscopes.**

## » 3.1 Transport

At the RDGG ambulatory clinic, 38 endoscopies per week are performed. For disinfection of these endoscopes, 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 2772 kilometres per year are driven for disinfection of these endoscopes, emitting 512 kilograms of $CO_2$ per year. The method used at the main site does not require transport by bus, so there are no $CO_2$ emissions with this transport. With the UV Smart D60, no kilometres are driven either, which also means no $CO_2$ emissions from transport.

***"At the RDGG ambulatory clinic, 38 endoscopies per week are performed."***

**Table 2**

Usage water, chemicals, energy and $CO_2$.

| WD | Per 2 endoscopes | 1596 endoscopes ambulatory clinic | 3654 endoscopies main location |
|---|---|---|---|
| **Chemicals 2,8 kg $CO_2$ / liter** | 600 ml<br>1,68 kg $CO_2$ per 600 ml | 478.8L<br>1340 kg $CO_2$ | 1096 liter<br>3069 kg $CO_2$ |
| **Water 0.3 kg $CO_2$ / liter** | 3 liter<br>0.9 kg $CO_2$ | 2394L<br>718 kg $CO_2$ | 5481L<br>2466.4 kg $CO_2$ |
| **Energy consumption** | 1800 watt<br>1.8 kwh<br>0.82 kg $CO_2$ | 1.436.400 Watt<br>1436 KwH<br>654,82 kg $CO_2$ | 3.288.600 Watt<br>3288 KwH<br>1499.3 kg $CO_2$ |
| **Kilometers driven 0.185 kg $CO_2$** | 11 kilometers<br>2,035 kg $CO_2$ per 11 km | 2772 kilometers<br>512 kg $CO_2$ | 0 kilometer<br>0 kg $CO_2$ |
| **Total $Co_2$** | **4.43 kg $CO_2$** | **3224,82 kg $CO_2$** | **7034,7 kg $CO_2$** |

| D60 | Per 2 endoscopes | 1596 endoscopes total | 3654 endoscopies main location |
|---|---|---|---|
| **Chemicals 2,8 kg $CO_2$ / liter** | 0<br>0 kg $CO_2$ | 0L<br>0 kg $CO_2$ | 0L<br>0 kg $CO_2$ |
| **Water 0.3 kg $CO_2$ / liter** | 0<br>0 kg $CO_2$ | 0L<br>0 gram $CO_2$ | 0L<br>0 kg $CO_2$ |
| **Energy consumption** | 1300 watt<br>0.59 $CO_2$ | 1.037.400 watt<br>1.037,2 Kwh<br>472,87 kg $CO_2$ | 2375100<br>2.375,1 KwH<br>1083 kg $CO_2$ |
| **Kilometers driven 0.185 kg $CO_2$** | 0 kilometer<br>0 kg $CO_2$ | 0 kilometer<br>0 kg $CO_2$ | 0 kilometer<br>0 kg $CO_2$ |
| **Total $CO_2$** | **0,59 kg $CO_2$** | **472,87 kg $CO_2$** | **1083 kg $CO_2$** |

**Table 3**
Comparison time of disinfection with the WD and the UV Smart D60.

| Fase | WD | 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 | The endoscope is pre-cleaned immediately after consultation; | 1 minute | The endoscope is pre-cleaned immediately after consultation; | 1 minute |
| 3 | Endoscope is placed in transport tray and locked and collected for transportation; | 5 minutes | The endoscope 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 endoscopes 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 endoscopes with a damp microfiber cloth (with water) for 20 seconds; | 20 seconds |
| 6 | Then the endoscope is placed in the Medicator Advantage Plus Pass Thru for 40 minutes | 40 minutes | The endoscope is then exposed to the UV-C light for 60 seconds while suspended (Rudhart, 2021); | 1 minute |
| 7 | After disinfection, the endoscope is placed in transport container, locked and transported back to the outpatient clinic. | 25 minutes | After the disinfection cycle, the endoscope can either be used immediately or transported back to the patient room. | 5 minutes |
| | **Total with the WD** | **96 minutes** | **Total with the UV Smart D60** | **12 minutes** |

## » 3.2 Chemicals, water and energy

Research shows that disinfection with the WD in the RDGG consumes 478.8 litres of chemicals per year and 1340 kg $CO_2$ for disinfection of endoscopes at theambulatory clinic, in addition it consumes 1096 litres of chemicals and 3069 kg $CO_2$ per year for the Main Location. The UV Smart D60 consumes 0 litres of chemicals and 0 kg $CO_2$ per year for disinfection of endoscopes at the ambulatory clinic (table 2).

In addition, the study shows that the WD for the ambulatory clinic consumes 2652 litres of water per year and 718 kg $CO_2$, for Main location the WD consumes 5481 litres of water and 2466 kg $CO_2$, the UV Smart D60 consumes 0 litres of water and 0 kg $CO_2$ for disinfection of endoscopes.

Furthermore, for the ambulatory clinic, the WD consumes 1,436,400 watts and 1436 kg $CO_2$ per year, for main location 3,288,600 and 1499 kg $CO_2$, and the UV Smart D60 3,412,500 watts and 472.87 kg $CO_2$ 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 an endoscope with the WD 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

**$CO_2$ emissions from health care are significant. Several processes within healthcare contribute to these $CO_2$ 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 $CO_2$ 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, 1547 liters of chemicals, 7875 liters of water, 3686.8 KWh of energy, and 2772 kilometers of transportation can be saved annually. If you convert this to $CO_2$ emissions, as shown in table 5, you can see that by purchasing the D60, 8703.65 kilograms of $CO_2$ 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, 1547 liters of chemicals, 7875 liters of water, 3686.8 KWh of energy, and 2772 kilometers of transportation can be saved annually. If you convert this to CO2 emissions, as shown in table 5, you can see that by purchasing the D60, 8703.65 kilograms of CO2 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 | **1.547,8 liters** |
| **Water** | 2394 liters | 5.481 liters | 0 | **7875 liters** |
| **Energy consumption** | 1436 KWh | 3288 KWh | 1037,2 KWh | **3686,8 KWh** |
| **Kilometers** | 2772 kilometers | 0 | 0 | **2772 kilometers** |

**Tabel 5**
$CO_2$ savings per year

| Per year | Ambulatory Clinic | Main location | UV Smart D60 | Total savings WD versus UV Smart D60 |
|---|---|---|---|---|
| **Chemicals** | 1340 kg $CO_2$ | 3069 kg $CO_2$ | 0 kg $CO_2$ | **4409 kg $CO_2$** |
| **Water** | 718 kg $CO_2$ | 2466.4 kg $CO_2$ | 0 kg $CO_2$ | **3184,4 kg $CO_2$** |
| **Energy consumption** | 654,82 kg $CO_2$ | 1499.3 kg $CO_2$ | 1555,87 kg $CO_2$ | **598.25 kg $CO_2$** |
| **Kilometers** | 512 kg $CO_2$ | 0 kg $CO_2$ | 0 kg $CO_2$ | **512 kg $CO_2$** |
| **Total savings WD versus UV Smart D60** | | | | **8703.65 kg $CO_2$** |

## » 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 endoscopes at the main location is 96 minutes, whereas at the Head 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 endoscopes at the Head location, 2.5 FTE per year can be saved.

***"If a UV Smart D60 is used for disinfection of flexible channel-less endoscopes at the Head location, 2.5 FTE per year can be saved."***

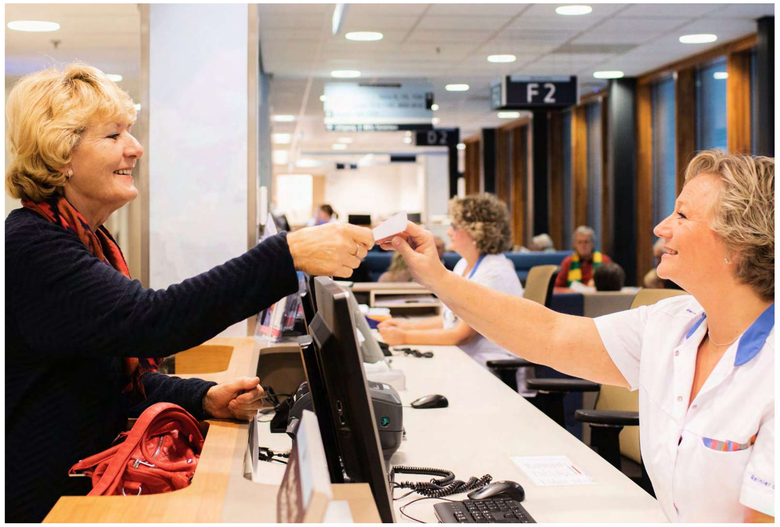



**Table 6**
Savings in hours per year

| | Ambulatory Clinic | Main location |
|---|---|---|
| **Turnaround time of 1 endoscope** | 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 $CO_2$ reduction analysis has shown that disinfection of channel-less endoscopes 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 endoscopes 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 an endoscope at their disposal. This ultimately leads to better diagnosis.

***"With the UV Smart D60, endoscopes can be disinfected on-site, reducing the need for transportation."***

Currently, endoscopes are often transported to other locations for disinfection. This carries the risk of damage to endoscopes, which can lead to higher repair and replacement costs and potentially loss of use time. With the UV Smart D60, endoscopes can be disinfected on-site, reducing the need for transportation. This can lead to a reduction in endoscope 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 disinfection washer 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 endoscopes 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 endoscope disinfection are outdated. In the Netherlands, UV-C disinfection is included in the Steering Group for Flexible Endoscope Cleaning and Disinfection (SFERD, 2022). However, UV-C 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 $CO_2$-reduction analysis, two methods for disinfecting flexible channel-less endoscopes have been evaluated. The UV-C system 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.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
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