Original research

Environmental impact of single-use versus reusable gastroscopes

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ABSTRACT

Introduction The environmental impact of endoscopy is a topic of growing interest. This study aimed to compare the carbon footprint of performing an esogastroduodenoscopy (EGD) with a reusable (RU) or with a single-use (SU) disposable gastroscope.
Methods SU (Ambu aScope Gastro) and RU gastroscopes (Olympus, H190) were evaluated using life cycle assessment methodology (ISO 14040) including the manufacture, distribution, usage, reprocessing and disposal of the endoscope. Data were obtained from Edouard Herriot Hospital (Lyon, France) from April 2023 to February 2024. Primary outcome was the carbon footprint (measured in Kg CO_2 equivalent) for both gastroscopes per examination. Secondary outcomes included other environmental impacts. A sensitivity analysis was performed to examine the impact of varying scenarios.
Results Carbon footprint of SU and RU gastroscopes were 10.9 kg CO_2 eq and 4.7 kg CO_2 eq, respectively. The difference in carbon footprint equals one conventional car drive of 28 km or 6 days of CO_2 emission of an average European household. Based on environmentally-extended input-output life cycle assessment, the estimated per-use carbon footprint of the endoscope stack and washer was 0.18 kg CO_2 eq in SU strategy versus 0.56 kg CO_2 eq in RU strategy. According to secondary outcomes, fossil eq depletion was 130 MJ (SU) and 60.9 MJ (RU) and water depletion for 6.2 m^3 (SU) and 9.5 m^3 (RU), respectively.
Conclusion For one examination, SU gastroscope have a 2.5 times higher carbon footprint than RU ones. These data will help with the logistics and planning of an endoscopic service in relation to other economic and environmental factors.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Single-use (SU) endoscopes reduce the risk of scope contamination and can be one solution when scope availability is a barrier to service provision. However, there are concerns regarding the ecological impact of their adoption. Previous evaluations have indicated that the precise type of scope used has an important bearing on net environmental impact, but that further independent evaluation is required.

WHAT THIS STUDY ADDS

⇒ This study is the first comparison of SU versus reusable scopes for upper gastrointestinal endoscopy reporting on carbon footprint and other ecological impacts including water consumption, water toxicity, acidification and eutrophication. Although SU scopes are associated with a larger carbon footprint in most circumstances, this trend may be reversed when their use facilitates shorter journeys for patients travelling for care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This design and conduct of this study were dependent on novel collaboration between endoscopists and those with expertise in environmental impact assessment. It is also an example of how two clinical strategies can be compared using life cycle assessment methodology.

INTRODUCTION

There is growing concern with regard to the environmental impacts associated with the provision of endoscopy services.[1–4] Recent assessments have ranked gastrointestinal (GI) endoscopy as the third highest generator of hazardous healthcare waste in a hospital.[5] The environmental impact of GI endoscopy has led the European Society of Gastrointestinal Endoscopy to establish sustainable endoscopy practices as a major objective within our field.[6]

In recent years, single-use (SU) endoscopes have been marketed as a potential option in several scenarios,[7] including when the immediate availability of an endoscope is required, when contamination risks are a particular concern and to meet a strategic objective to move clinical care closer to the patient. But the adoption of this equipment, which is disposed after each use, has raised ecological concerns.[1 2 4] In a study comparing SU and reusable (RU) ureteroscopes, the balance was slightly in favour of the SU instrument due to the

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environmental burden of decontamination and reprocessing.[8] Opposite findings were reported with the use of SU duodenoscopes, which were estimated to have a 47-fold higher environmental impact compared with RU duodenoscopes.[9] Our study aims to estimate carbon emissions generated by SU gastroscopes compared with RU gastroscopes using a comprehensive life cycle assessment (LCA). We also aim to examine the environmental impacts associated with the reprocessing and waste management of SU and RU endoscopes.

METHODS

Study design

From April 2023 to February 2024, an LCA was performed independently by a dedicated company (APESA, Bayonne, France) with ISO 9001 and 14001 certification.[10] The decontamination protocol at Edouard Herriot Hospital (Lyon, France) was used as the model for endoscopic reprocessing. We designed a prospective evaluation study with two different phases:

1. A process-based LCA to quantify the environmental impacts associated with an SU or RU gastroscope when used for an EGD.
2. An environmentally-extended input-output LCA (EEIO LCA) was conducted to estimate the environmental impact of the endoscopy stack system (processor, screen, trolley), inflators and washers used in each scenario (SU and RU).

An LCA was performed for each of the two different strategies of performing an EGD with either:

1. SU gastroscope—aScope Gastro (Ambu, Denmark).
2. RU gastroscope—H190 (Olympus, Tokyo, Japan) and its disinfection process using a washer (Serie 4, Soluscope, Aubagne, France).

Life cycle assessment

Aims and scope

The primary aim of the study was to quantify the environmental impact associated with both SU and RU endoscope strategies based on the ISO 14040:2006—3-5 framework.[11] The two endoscopes were analysed by an LCA. The boundary of the LCA analysis is presented in figure 1.

The secondary aims were:

1. Evaluate the carbon footprint of an endoscopy system (processor and light source on trolley) in the two settings using EEIO LCA (monetary ratio): SU—aBox system (Ambu, Ballerup, Denmark), RU—EVIS X1 system (Olympus, Tokyo, Japan).
2. Evaluate the carbon footprint of a washer for a RU endoscope (Soluscope Serie 4, Aubagne, France) using EEIO LCA.

Boundary of the LCA

Included data

The functional unit of analysis was the provision of an endoscope for one upper GI endoscopy. In both scenarios, the life cycle stages included were (1) manufacturing of the instrument from its raw material to its assembly, (2) distribution, (3) its disposal (cradle-to-grave). For the SU scope, the transport of the endoscope from manufacturer to distributor and from distributor to our unit were also considered in the analysis. For the RU gastroscope, reprocessing was studied by following the endoscope after its use to record all supplies, disinfectants and detergents used during all process steps of reprocessing (handling, predisinfection, disinfection and storage). In France, two cycles of scope disinfection are recommended during the washing phase and were included in this analysis. Weight and composition of all consumable materials used for reprocessing of one gastroscope were weighed and analysed as follows. The impact analysis according to storage in a box or in a dryer cabinet were also measured.

Excluded data

The periprocedural management (preprocedural and postprocedural care, patient and staff travel, sedation), the additional supplies (bite block, energy for heating, ventilation and air conditioning, lighting and energy needs of an endoscopy unit, washers and cabinet) and additional devices used during the endoscopy

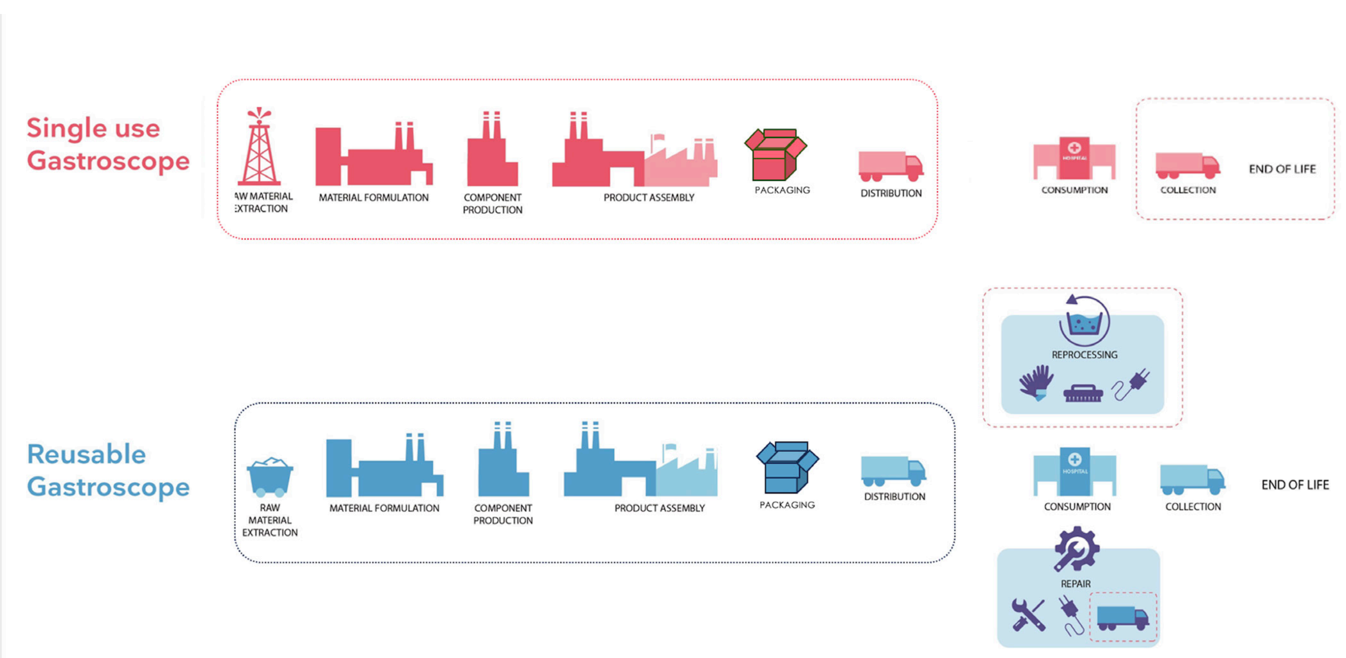

Figure 1 Diagram of the lifecycle analysis for reusable (A) and single used (B) scope.

Table 1 Environmental impacts of the life cycle assessment of single-use scope

Impact	Unit	Total	Component production	Assembly and sterilisation	Supply manufacturer (Malaysia)	Supply distributor	Packaging	End of life treatment
Climate change Carbon footprint	kg CO_2 eq	10,9	5.7	1.4	0.2	0.1	1.5	2.1
Depletion fossil resources	MJ	130	79	16	2.8	1.6	21	9
Freshwater ecotoxicity	kg 1,4 DB eq	15.9	13.9	0.5	0.03	0.02	0.8	0.6
Terrestrial Acidification	kg SO_2 eq	0.12	0.106	0.005	0.005	0 .0003	0.004	0.003
Eutrophication	kg PO4--- eq	0.02	0.0105	0.002	0.0006	0.00008	0.0016	0.002
Water consumption	m^3	6.2	5.22	0.2	0.005	0.005	0.5	0.2

procedure (eg, forceps) were not included in the analysis since they do not differ in the two strategies.

Data inventory and assumptions

Material composition data pertaining to the SU gastroscope was supplied in confidence by the manufacturer to the company conducting the analysis (APESA, Bayonne, France) given the need to maintain confidentiality with regard to the device manufacture.

For the RU strategy, the manufacturer disclosed the material composition which was then analysed by an independent team (HP) and then validated independently by APESA (HP).[1] The mean lifetime uses of a gastroscope and the time between each repair were determined through an audit of all gastroscopes in our unit (data of use are currently available for each endoscope).

Statistical analysis

Life cycle assessment

The environmental impacts of both SU and RU gastroscopes were modelled using the SimaPro V.9.3 LCA tool with the ecoinvent V.3.8 Life Cycle Inventory (LCI) database. An LCI was compiled of all process steps from manufacturing to disposal. The method CML-baseline V.3.07 was used to characterise the emissions and combine them into the following midpoint impacts:

- Greenhouse gas (GHG) emissions (kg CO_2 eq).[12]
- Water consumption (m^3), using AWARE methodology.[13]
- Abiotic depletion potential for fossil resource (MJ).[14 15]
- Freshwater eutrophication potentials (kg PO4-equivalents to freshwater-equivalents).[16]
- Terrestrial acidification (kg SO_2 eq).[17]
- Freshwater ecotoxicity (kg 1,4-dichlorobenzene-equivalent s).[18]

System and washer carbon footprint

No specific processes are available in lifecycle databases to evaluate the environmental impacts of the endoscopy system (screen and trolley, EVIS X1) and washer using process-based LCA. We therefore used EEIO LCA,[19] a monetary ratio, whereby the price of a product is used to estimate its environmental impact. The EEIO uses a conversion factor that is related to the economic sector in which the product is manufactured. We applied the purchase cost in Euros (€) and used the mean price of the system as quoted by the manufacturer without reduction.

Simulations

Simulations were run by varying the number of procedures performed per year in the centre assuming a 10-year whole life expectancy of the system (processor and light source), inflator and washer.

The effect of varying travel distance by patients using fuel cars was also modelled. We used a GHG emission factor of 0.22 kg CO_2 eq/km according to the mean impact of a fuel car in France evaluated by the French national agency of the ecological transition (ADEME).[20] Car travel was used since it represents more than 75% of the transport mode to access to screening endoscopy procedures in previous French evaluations.[21]

Descriptive statistics are described as absolute (n) and relative frequencies (%) for categorical variables. Uncertainties around the impact calculation was done using the Monte Carlo method[22] (online supplemental tables S2 and S3).

RESULTS

SU endoscope

The composition of an SU endoscope (aScope Gastro Ambu) with a weight of 554 g was: 74% plastic (412 g); 24% metal (133.6 g); 0.8% electronics (4.4 g); 0.2% paper (1 g) and 0.4% other components (2.4 g). The primary packaging supplied with each scope weighed 411 g (403 g of plastic, 2.5 g of paper and 5.6 g of other components). In addition, for every six endoscopes an instruction form (86 g) and secondary packaging was included (313 g; 310 g cardboard, 3.5 g plastic and 0.15 g paper), adding 51.7 g of cardboard, 14.3 g of paper and 0.6 g of plastic to the weight of the endoscope.

Per use, the SU endoscope was associated with the following environmental impacts: 10.9 kg CO_2 eq GHG generation (carbon footprint), 130 MJ of fossil resource depletion and 6.2 m^3 of water consumption (table 1). The production of SU endoscope components was the biggest driver of environmental

Table 2 Environmental impacts of the life cycle assessment of reusable scope for one procedure

Impact	Unit	Total	Scope production and assembly	Primar packaging	Supply	Decontamination	Sent for repair	Sampling	End of life treatment
Carbon footprint	kg CO_2 eq	4.7	0.02	0.4	0.05	2.1	0.06	0.01	2.1
Depletion fossil resources	MJ	60.9	0.19	5.8	0,8	43.6	1.2	0.2	9.4
Freshwater ecotoxicity	kg 1,4 DB eq	2.6	0.04	0.2	0.01	1.7	0.05	0	0.6
Terrestrial Acidification	kg SO_2 eq	0.02	0.0001	0.001	0.0002	0.01	0.0004	0	0.003
Eutrophication	kg PO4--- eq	0.005	0.00005	0.0004	0.00004	0.003	0.00007	0.00001	0.002
Water consumption	m^3	9.5	0.00001	0.2	0.001	8.9	0.2	0	0.2

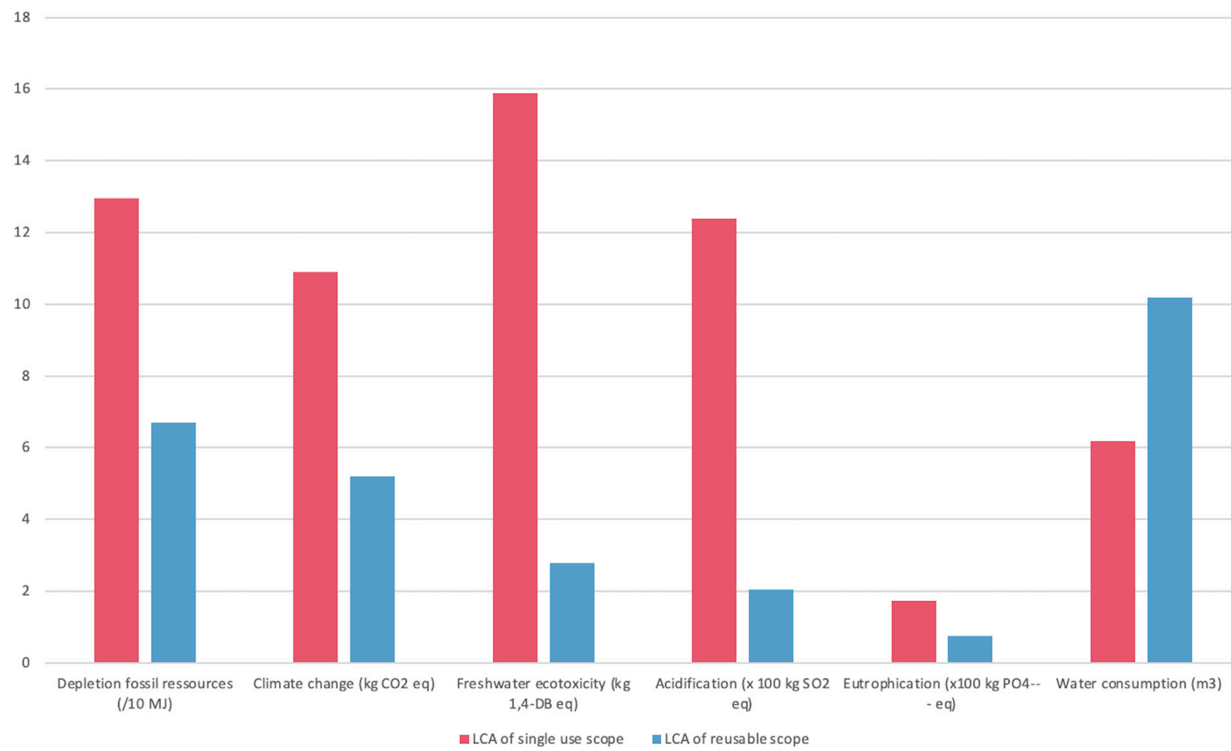

Figure 2 Schematic representation of the different impacts of single use vs reusable endoscopes.

impacts responsible for 61% of fossil resource depletion (79/130 MJ), 52% of the carbon footprint (5.7/10.9 kg CO_2 eq) and 84% of water depletion (5.2/6.2 m^3). The assembly and sterilisation phase generated respectively 2% and 15% of freshwater ecotoxicity for fossil resource consumption of the life cycle impacts. The impacts of packaging represented 3% of fossil resource depletion and had an almost negligible effect on the other impacts. Details of LCA results for SU are shown in table 1.

Reusable endoscope

At Hospices Civils de Lyon, one gastroscope (H190 Olympus) is used for an average of 1280 procedures over its 6-year lifespan. On average, 4.25 repairs or instrument services were needed during the lifetime of a gastroscope, which requires a round trip to the endoscope repair centre in Paris where some components are changed (return distance, Lyon–Paris 630 km using a small truck). When the emissions generated from manufacture and repair are allocated across the number of lifetime uses, the carbon footprint of the RU endoscope is 0.018 kg CO_2 eq per use, an impact considered negligible in relation to other emissions. At the end of the endoscope's lifetime, the instrument and non-recyclable packaging materials were incinerated. Packaging cardboard and paper was recycled. When the decontamination process is included in the environmental impact analysis, the carbon footprint of the RU endoscope is 4.7 kg CO_2 eq per use, with 61 MJ of fossil resource depletion and 9.5 m^3 of water depletion (table 2). The decontamination of the endoscope is the main driver of environmental impacts of the RU gastroscope (figure 2). Impacts related to disposable devices used in reprocessing are displayed in online supplemental table S1.

Reprocessing

Reprocessing of one RU endoscope generated 2.1 kg CO_2 eq GHG (carbon footprint) and was associated with the depletion of 43.6 MJ of fossil resource (table 2, online supplemental table S1). In France, two cycles of endoscope disinfection are recommended and were included in the present LCA. However, the environmental impact of the second disinfection cycle (cycle 2) was estimated at 0.27 kg CO_2 eq GHG (carbon footprint) and 5.3 MJ of fossil resource depletion and should be subtracted from the net environmental impact of decontamination in the countries where only one cycle is recommended.

The end-of-life treatment of personal protective equipment generated 2% (water consumption) to 45% (carbon footprint) of the environmental impacts. The impact of sending the equipment for repair and bacteriological sampling can be considered negligible.

Taken together, the processes with the greatest contribution to GHG emissions in each scenario were the production stage for the SU scope (6.6 kg CO_2 eq, 56.0%) and the decontamination stage for the RU scope (2.1 kg CO_2 eq, 44.7%).

Differential impact of SU versus RU endoscopes

Per procedure, when compared with RU endoscopes, SU endoscopes generate an additional 6.2 kg CO_2 eq and 69 MJ of fossil fuel depletion, but saved 4.1 m^3 of water (figure 2, online supplemental material SM1). The added carbon footprint conferred by a SU gastroscope is equivalent to 28 km of travel in fuel car.

Carbon footprint of the endoscopy system, storage cabinet, CO_2 inflator and washer

The mean price of an endoscopy system EVIS X1, storage cabinet, CO2 inflator and Soluscope Serie 4 washer were

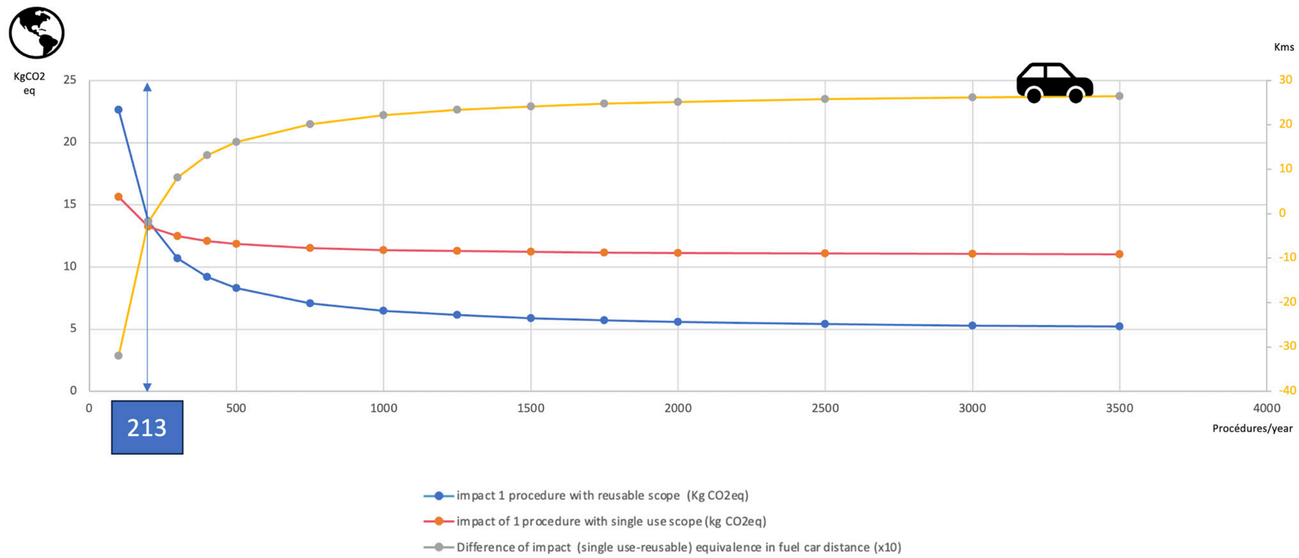

Figure 3 Impact on carbon footprint of the system, inflator and washer depending on the number of procedures performed per year considering a 10-year life expectancy of the system. Difference of impact represented in km (×10) travelled by the patient.

respectively €46 952, €39 302, €9055 and €22 198. The EEIO analysis estimates that such spending corresponds to a carbon footprint of 14 805, 12 379, 2835 and 6993 kg CO_2 eq. For the Ambu aBox system, with a mean price of €15 000, the carbon footprint was 4725 kg CO_2 eq. The CO_2 inflator is needed in the SU strategy (not provided in the aBox) and accounted for 2835 kg CO_2 eq. Most gastroscopies were performed with air inflation which is provided by the endoscopy system (no need of an additional inflator in RU strategy for upper GI endoscopy).

In our gastroscopy room, one endoscopy system and two washers are used simultaneously for a total of 2640 procedures per year for a maximal period of 10 years before renewal. When lifetime emissions are allocated per procedure, the carbon footprint is 0.56 kg CO_2 eq for the endoscopy system and a 0.27 kg CO_2 eq for each washer. For the same number of procedures, the aBox has a carbon footprint of 0.18 kg CO_2 eq and the inflator 0.1 kg CO_2 eq. The storage cabinet carried an additional impact of 0.56 kg CO_2 eq per use. Therefore, for one procedure in our unit, the difference in carbon footprint of the supporting equipment is 0.54 kg CO_2 eq (equivalent to 2.5 km in a fuel car). Figure 3 presents the results by number of procedures performed per year, assuming a 10-year life expectancy in a unit with one system and one washer. Assuming similar patient travel patterns, it is estimated that the conduct of 213 gastroscopies per year is the threshold at which RU endoscopes begin to confer a lower environmental impact than SU.

DISCUSSION

The environmental impact of gastroscopy is important whether the procedure is performed with an SU or RU endoscope. Unnecessary examinations, which in some series account for 40% of procedures performed,[23] must therefore be avoided to reduce our overall impact.

This environmental impact is increasingly discussed within the framework of organising an endoscopy unit, also with regards to possible infection prevention. Although the latter issue mainly relates to pancreatobiliary endoscopy, other studies have also shown possibly higher post-endoscopy infection rates in general.[24] While in general, the risk of post-endoscopy infection with upper and lower GI has not been considered relevant enough to suggest the universal use of SU scopes, organisational and logistical issues may also be of relevance: This relates to emergency endoscopy in the intensive care unit or other settings[25 26] avoiding transportation efforts as well as reprocessing problems outside of routine hours[27] or performance of certain procedures (ERCP) on busy days when reprocessing of the RU scopes on stock may take too long. In all instances, the issue of using SU endoscopes in larger units with 5000–10 000 endoscopies per year give rise to a substantial environmental burden. This is a complex issue and data include other medical sources of CO_2 production including endoscopies not indicated.[23] This has been addressed by statements of several GI endoscopy societies.[6 28]

To add data to this mosaic of newly forming evidence in GI endoscopy, we performed the first LCA of EGD with either SU or standard RU gastroscopes. With regard to the provision of a gastroscope ready for use, the SU strategy has a 2.5 folds higher environmental impact with an additional carbon footprint of 6.2 kg CO_2 eq and 69 MJ of fossil fuel depletion, but requires 3.3 m^3 less water due to the absence of reprocessing. The increased carbon footprint conferred by SU endoscopes was also demonstrated in a recent LCA study with reported a 47-fold higher impact[29] for SU when compared with RU duodenoscopes. However, contrary findings have been reported for lightweight endoscopes like ureteroscopes or laryngoscopes.[8 30] The main driver of environmental impact in the SU strategy is the production of the SU scope (accounting for 56% of the carbon footprint (online supplemental material SM4). New innovative manufacturing processes using bioplastics or recycled plastics should be evaluated to reduce this impact.

On the other hand, in the RU strategy, reprocessing is the most impactful process accounting for 45% of the carbon footprint and more than 90% of water consumption. New disinfection protocols should be explored with greater consideration of environmental impacts reducing water consumption but also the toxic chemistry and electrical consumption. New methods of washing with turbulent air flow and high-pressure water could considerably reduce water and chemical consumption[31] in the early phase of scope disinfection and are now under evaluation in prospective studies.

In an endoscopy centre already equipped with a system and washers, the RU strategy appears to carry less environmental impact. However, our results suggest that an individualised evaluation is needed for centres with a small number of procedures, particularly in isolated areas. For instance, a local general hospital in a small city, isolated from the main endoscopy centre and with very low endoscopic activity, using an SU scope could have less impact than an underused RU strategy. How this will be organised in the future is still an open option, but the environmental impact might be different with different organisational models.[27] In any way, both travel of patients and personnel has been shown to substantially contribute to the CO_2 footprint.[29]

This leads to the question of comparability of the CO_2 footprint of one upper GI endoscopy procedure. With regards to the travel mentioned above, we calculated an amount of a 28-km car drive (using conventional fuel-driven cars); unfortunately car driving is still the most frequent way of transport (75%[29]) in our country. Thus, in an endoscopic unit with some 3000 upper and 3000 lower GI endoscopies (assuming similar CO_2 footprints of both procedures), this would amount to approximately 170 000 km. If CO_2 consumption of an average French (or European) household would be taken as comparator, 10 tons are produced[31] which would equal 2000 conventional upper GI endoscopies using conventional scopes and half of the number using SU instruments.

The environmental impact of routine endoscopic procedures is not limited to the procedure itself. When ecological burden is considered, the scope of the analysis must be enlarged to encompass the whole procedure including the indication, the patient journey and the devices used during the endoscopy. For example, the amount of waste generated by dilation or stent placement varies greatly depending on the strategy chosen. Dilation with a SU cap-candle generates only 4 g of waste compared with 480 g with a hydrostatic balloon,[32] and RU strategies with a Savary's bougie is also a low waste option.[33] It is therefore imperative to keep in mind that our entire approach must remain eco-responsible and rather than a sole focus on the endoscope whose plastic weight is less than that of the whole balloon dilation system (balloon and manometer handle).

Our study has some limitations including the fact that the quality of the endoscopy and its clinical impacts were not evaluated. The latest RU endoscopes have a higher optical performance (HD, zoom, chromoendoscopy) than SU endoscopes, although many centres with low caseloads are using very old scopes which lack those features given the financial constraints on investment in new equipment.

We were not able to conduct the environmental impact analysis ourselves as the composition of the two devices was not disclosed to us, but both endoscopes were independently evaluated by two laboratories. In the RU strategy, the impact of scope manufacturing is divided by a high number of procedures and is therefore almost negligible. Another limitation is the lack of evaluation of the use of the same endoscopy system across other disciplines like anaesthesiology, urology or ENT surgery that could mutualise the system use for more procedures in small centres. This could also be applied to SU strategy since aBox is also compatible with scopes for other disciplines like anaesthesiology (laryngoscope), urology (ureteroscope). A 10-year life expectancy was assumed for the endoscopy system (processor and light source), but this could be shorter in SU strategy as companies advocate for design changes to rapidly implement new technologies. If one SU scope does not use more space than one RU one that needs a transport and a drying box, the surface area (and therefore the impacts of storage) used in the endoscopy unit could be different in the two strategies (online supplemental material SM5), but depends on the number of SU endoscopes to be stored to ensure the smooth running of routine endoscopy activity.

In conclusion, the SU endoscope carries a 2.5-fold greater environmental impact per procedure with regard to its carbon footprint and fossil resource depletion. This data should be balanced against other factors; we currently believe that the SU strategy does not seem sustainable in routine practice especially in larger centres, but could be of interest for some indications to supplement conventional scopes or for use in some more remote areas to reduce patients' travel.

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Contributors Conceived and designed the analysis: MP, AL, HP, JACN, AB. Collected the data for the life cycle assessment: MP, P-JC, AB, DG. Contributed data or analysis tools: P-JC, AL, ERdS, HP, JR. Performed the analysis: AL, HP, ERdS. Drafted the paper: HP, ERdS, MS, JACN, RB. English native speaking edition and revision of the manuscript: RB, HP. Guarantor: MP.

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Competing interests ERdS: Olympus Educational activity and advisory work, Apollo Endosurgery Educational activity, Norgine Conference fees and educational activity, Casen Conference fees. MP: Consultant for Olympus, trainer for Olympus, Pentax, Norgine, Boston, Cook. Other authors have nothing to disclose.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

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Supplementary material : *Environmental impacts of the life reusable scope reprocessing with all the single use devices analysez.*

Impacts	Unit	Total	Plastic glasses	Detersion brush	Sterile water	Double swab	Endogator	Long Gloves	Table cloth	NT PP	Classic gloves	Syringue 10 ml	Syringue 50 ml	single use valv	Tablier blanc 69 x	glass visor	Cycle 2	Cycle 1	Cycle 4	Cycle 6	Detersion	Storage ESET
Climate change Carbon footprint	**kg CO2 eq**	2,11	0,05	0,05	0,15	0,06	0,01	0,14	0,14	0,01	0,22	0,01	0,08	0,01	0,02	0,02	0,27	0,18	0,16	0,31	0,15	0,08
Depletion fossil ressources	**MJ**	43,57	0,55	1,10	3,20	0,73	0,17	2,88	3,16	0,15	4,49	0,19	1,94	0,17	0,54	0,25	5,27	4,23	4,01	7,90	1,66	0,98
Freshwater ecotoxicity	**kg 1,4-DB eq**	1,72	0,00	0,02	0,06	0,45	0,00	0,01	0,06	0,00	0,01	0,00	0,03	0,00	0,01	0,00	0,22	0,14	0,11	0,21	0,14	0,25
Terrestrial Acidification	**kg SO2 eq**	0,0137	0,0002	0,0002	0,0005	0,0048	0,0000	0,0003	0,0005	0,0000	0,0005	0,0000	0,0003	0,0000	0,0001	0,0001	0,0015	0,0009	0,0008	0,0015	0,0010	0,0004
Eutrophication	**kg PO4--- eq**	0,00268	0,00002	0,00005	0,00014	0,00019	0,00001	0,00005	0,00014	0,00001	0,00008	0,00001	0,00009	0,00001	0,00002	0,00001	0,00046	0,00028	0,00024	0,00045	0,00028	0,00014
Water consumption	**m3**	8,90	0,01	0,03	0,08	0,20	0,00	0,08	0,07	0,00	0,12	0,00	0,04	0,00	0,01	0,01	2,30	2,01	1,39	1,75	0,74	0,04

Description of the different washing cycles : Cycle 1 : ; Cycle 2: ; Cycle 3: ; Cycle 4

Endogator is a single use connecting tube for endoscope washing (1 per washing)

Supplementary materials : Uncertainties around the impact calculation (Monte Carlo method): single use scope.

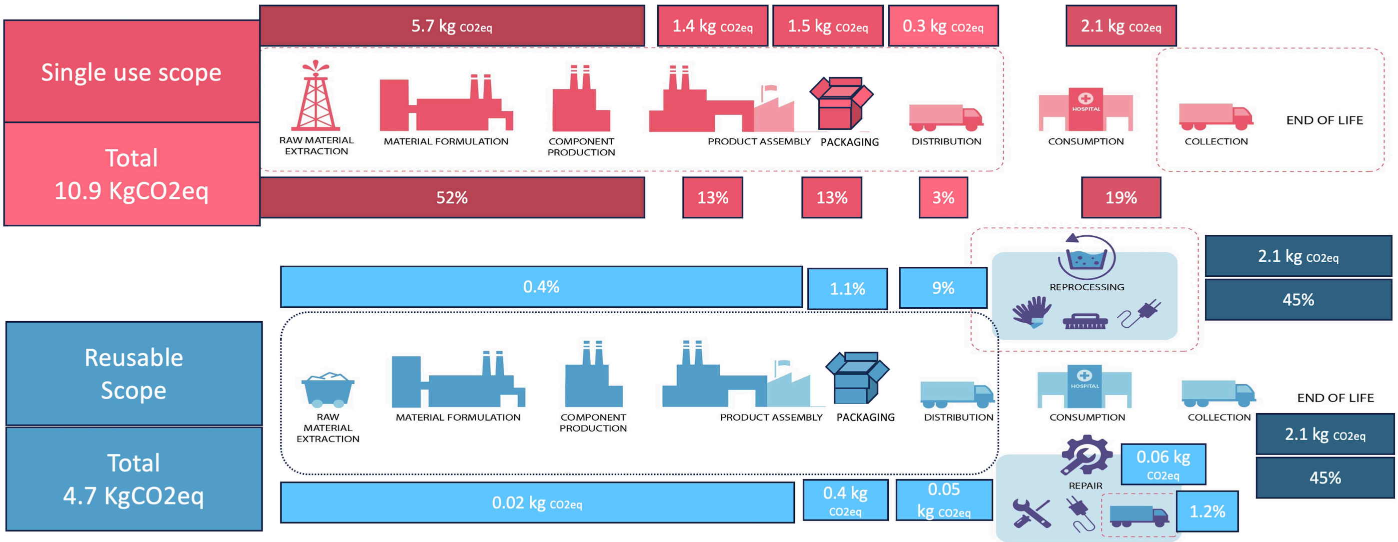
Impact	Unit	Mean	Median	SD	CV (%)	2,50%	97,50%	SEM
Climate change	kg CO2 eq	11,86	11,86	0,50	4	10,93	12,91	0,02
Fossil resources depletion	MJ	140,11	139,79	5,43	4	129,65	151,51	0,17
Ecotoxicity	kg 1,4-DB eq	21,54	21,70	5,53	26	10,41	32,78	0,17
Acidification	kg SO2 eq	0,13	0,13	0,01	11	0,11	0,16	0,00
Eutrophication	kg PO4--- eq	0,02	0,02	0,01	24	0,01	0,04	0,00
Water consumption	m3	8,00	12,04	70,12	876	-142,60	134,46	2,22

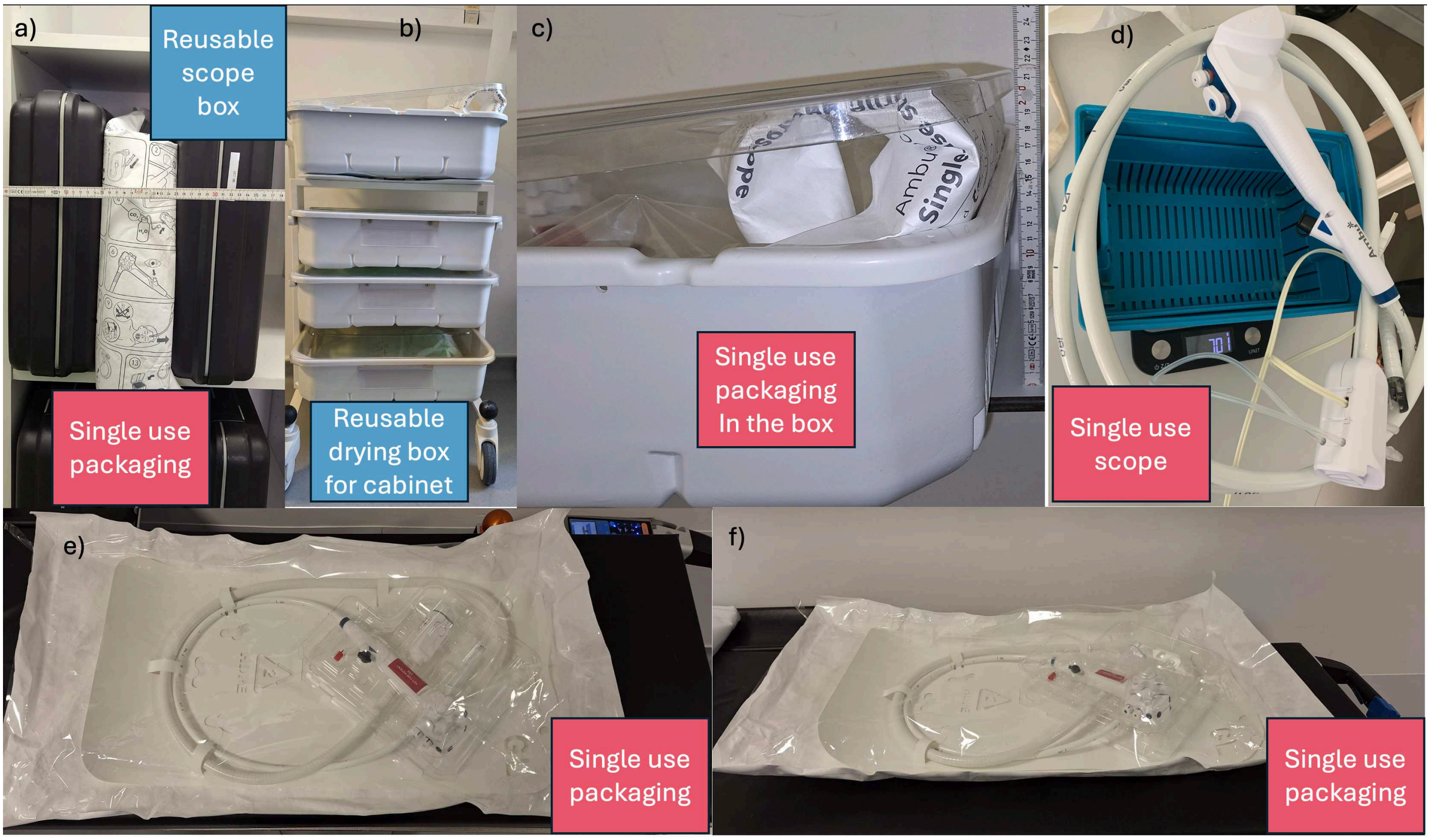
SD : standard deviation ; CV : ; SEM :

Supplementary materials S2 : Uncertainties around the impact calculation (Monte Carlo method): reusable scope.

Impact	Unit	Mean	Median	SD	CV (%)	2,50%	97,50%	SEM
Climate change	kg CO2 eq	4,85	4,81	0,31	6	4,36	5,56	0,01
Fossil resources depletion	MJ	62,9	62,4	4,4	7	55,8	72,9	0,1
Ecotoxicity	kg 1,4-DB eq	2,52	2,46	0,53	21	1,69	3,68	0,02
Acidification	kg SO2 eq	0,0183	0,0182	0,0013	7	0,0161	0,0211	0,0000
Eutrophication	kg PO4--- eq	0,00563	0,00527	0,00179	32	0,00349	0,01046	0,00006
Water consumption	m3	11,24	12,61	23,55	211	-39,07	55,36	0,74

SD : standard deviation ; CV : ; SEM :


Single use scope
Total
10.9 KgCO2eq
5.7 kg CO2eq
1.4 kg CO2eq
1.5 kg CO2eq
0.3 kg CO2eq
2.1 kg CO2eq
RAW MATERIAL EXTRACTION
MATERIAL FORMULATION
COMPONENT PRODUCTION
PRODUCT ASSEMBLY
PACKAGING
DISTRIBUTION
CONSUMPTION
COLLECTION
END OF LIFE
52%
13%
13%
3%
19%
REPROCESSING
2.1 kg CO2eq
45%
0.4%
1.1%
9%
Reusable Scope
Total
4.7 KgCO2eq
RAW MATERIAL EXTRACTION
MATERIAL FORMULATION
COMPONENT PRODUCTION
PRODUCT ASSEMBLY
PACKAGING
DISTRIBUTION
CONSUMPTION
COLLECTION
END OF LIFE
2.1 kg CO2eq
45%
REPAIR
0.06 kg CO2eq
0.02 kg CO2eq
0.4 kg CO2eq
0.05 kg CO2eq
1.2%


a)
Reusable scope box
Single use packaging
b)
Reusable drying box for cabinet
c)
Single use packaging In the box
d)
Single use scope
e)
Single use packaging
f)
Single use packaging

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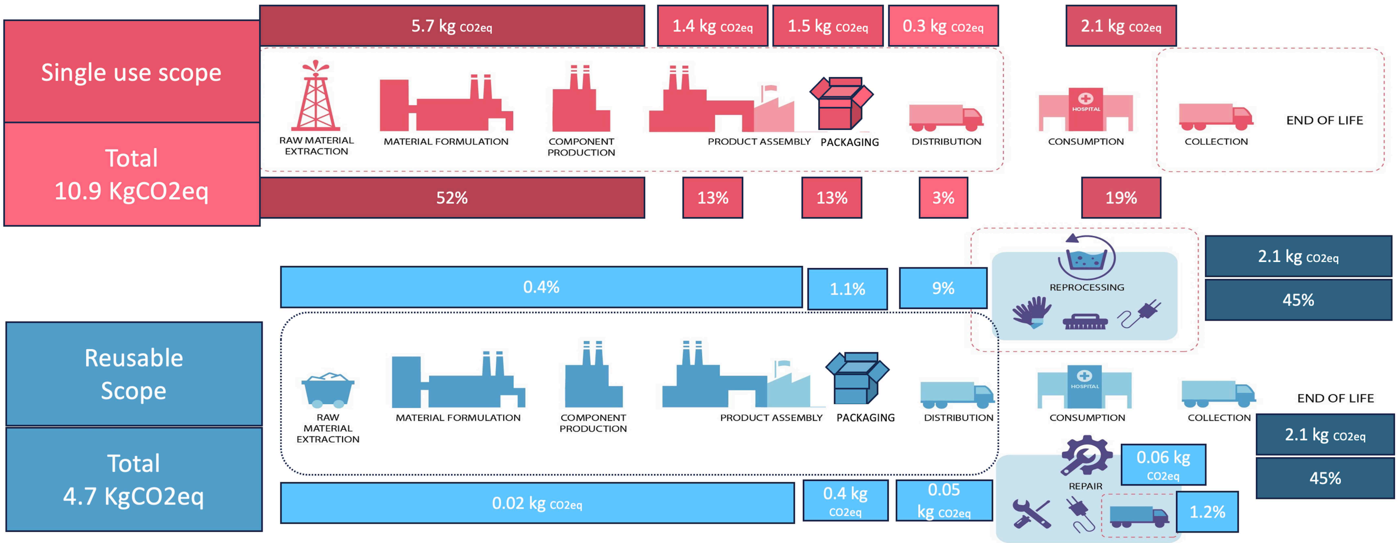
Single use scope
Total
10.9 KgCO2eq
5.7 kg CO2eq
1.4 kg CO2eq
1.5 kg CO2eq
0.3 kg CO2eq
2.1 kg CO2eq
RAW MATERIAL EXTRACTION
MATERIAL FORMULATION
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13%
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REPROCESSING
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0.4%
1.1%
9%
Reusable
Scope
Total
4.7 KgCO2eq
RAW MATERIAL EXTRACTION
MATERIAL FORMULATION
COMPONENT PRODUCTION
PRODUCT ASSEMBLY
PACKAGING
DISTRIBUTION
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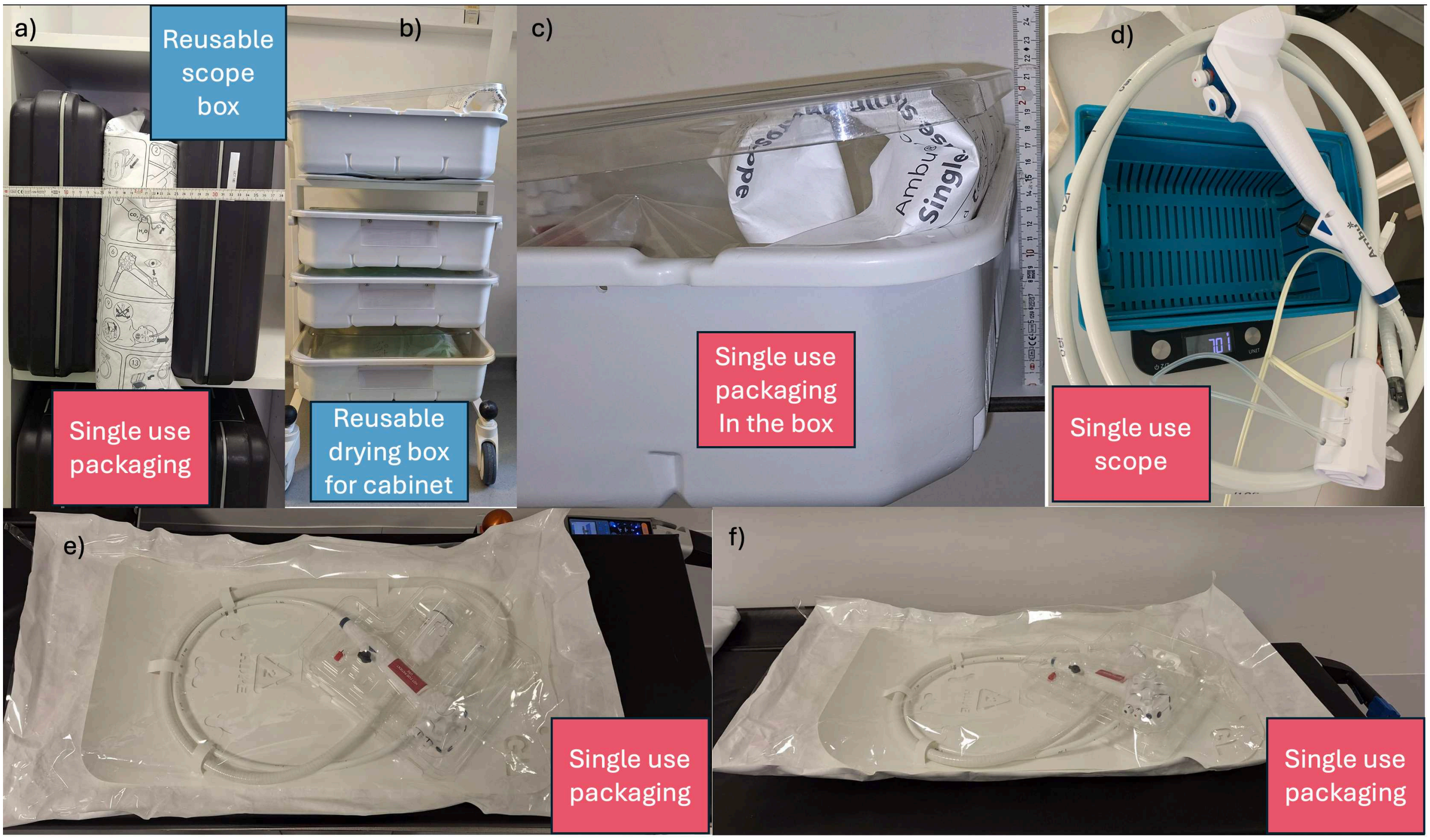
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