Reducing the environmental footprint of gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA) Position Statement

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ABSTRACT

Climate change and the destruction of ecosystems by human activities are among the greatest challenges of the 21st century and require urgent action. Health care activities significantly contribute to the emission of greenhouse gases and waste production, with gastrointestinal (GI) endoscopy being one of the largest contributors. This Position Statement aims to raise awareness of the ecological footprint of GI endoscopy and provides guidance to reduce its environmental impact. The European Society of Gastrointestinal Endoscopy (ESGE) and the European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA) outline suggestions and recommendations for health care providers, patients, governments, and industry. **Main statements 1** GI endoscopy is a resource-intensive activity with a significant yet poorly assessed environmental impact. **2** ESGE-ESGENA recommend adopting immediate actions to reduce the environmental impact of GI endoscopy. **3** ESGE-ESGENA recommend adherence to guidelines and implementation of audit strategies on the appropriateness of GI endoscopy to avoid the environmental impact of unnecessary procedures. **4** ESGE-ESGENA recommend the embedding of reduce, reuse, and recycle programs in the GI endoscopy unit. **5** ESGE-ESGENA suggest that there is an urgent need to reassess and reduce the environmental and economic impact of single-use GI endoscopic devices. **6** ESGE-ESGENA suggest against routine use of single-use GI endoscopes. However, their use could be considered in highly selected patients on a case-by-case basis. **7** ESGE-ESGENA recommend inclusion of sustainability in the training curricula of GI endoscopy and as a quality domain. **8** ESGE-ESGENA recommend conducting high quality research to quantify and minimize the environmental impact of GI endoscopy. **9** ESGE-ESGENA recommend that GI endoscopy companies assess, disclose, and audit the environmental impact of their value chain. **10** ESGE-ESGENA recommend that GI endoscopy should become a net-zero greenhouse gas emissions practice by 2050.

ABBREVIATIONS

AI	artificial intelligence
ASGE	American Society of Gastrointestinal Endoscopy
EMR	endoscopic mucosal resection
ERCP	endoscopic retrograde cholangiopancreatography
ESD	endoscopic submucosal dissection
ESGE	European Society of Gastrointestinal Endoscopy
ESGENA	European Society of Gastroenterology and Endoscopy Nurses and Associates
EU	European Union
GI	gastrointestinal
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
KPM	key performance measure
PICO	population/problem, intervention, comparison, outcome
PVC	polyvinyl chloride
RCT	randomized controlled trial

SOURCE AND SCOPE

This Position Statement from the European Society of Gastrointestinal Endoscopy (ESGE) and the European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA) reviews the available data on the environmental impact of gastrointestinal endoscopy. It aims to raise awareness of this growing problem that demands urgent action and to outline strategies to achieve sustainable endoscopy practice ("green endoscopy").

1 Introduction

Climate change driven by human activities is an undeniable reality that already has visible effects on the environment and human health. We are witnessing an increasing frequency of extreme weather events such as hurricanes, droughts, heatwaves, floods, and an unprecedented extinction of species and loss of biodiversity. Due to human activities, the global temperature has risen by about 1.2 degrees Celsius (C) since the late 19th century, the Arctic Sea ice is steadily declining and has reached its minimum for at least the last 1000 years, and glaciers are retreating worldwide [1]. The years 2016 and 2020 were the warmest since temperatures have been recorded [1]. The Intergovernmental Panel on Climate Change (IPCC) of the United Nations, which comprises more than 1300 scientists, claims that global temperatures will rise during this century by up to 4–5 degrees C unless immediate action is taken, primarily due to the increase in human-driven greenhouse gas (GHG) production and the destruction of ecosystems [2].

Climate change has an insidious but relentless and significant adverse effect on health. Notably, high temperatures and air pollution have a synergistic negative impact on physical and psychological health [3]. An increase in morbidity and mortality from heatstroke, infectious disease, and exacerbations of cardiovascular and respiratory disease is expected due to global warming [3, 4]. Considering all the above, there is an urgent need for change. Governments, industries, institutions, individuals, and scientific societies can and must do more to face the environmental crisis.

Health care systems contribute significantly to the emission of GHGs [5]. Preliminary studies suggest that gastrointestinal (GI) endoscopy is one of the largest polluters and waste generators [6]. Currently, there is little awareness, assessment, or guidance from medical societies about the environmental impact of clinical practice. This Position Statement emphasizes the commitment of the European Society of Gastrointestinal Endoscopy (ESGE) and the European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA) to combating climate change. Therefore, the main aims of this document are to raise awareness of the ecological footprint of GI endoscopy and to provide guidance to reduce its environmental impact in clinical practice, education, and research.

2 Methods

This document has been developed in accordance with the current ESGE Publications Policy [7]. A Position Statement was considered appropriate given the anticipated lack of high quality evidence and the strategic relevance of the topic.

In August 2021, the project leaders (E.R. de S. and M.D.R.) proposed a preliminary list of questions and topics to all panelists and formed nine working groups. A virtual online meeting was held on 4 September, 2021, and a final list comprising 20 questions was approved. A structured template was developed to standardize the literature search and methods. Subsequently, we conducted a systematic literature search in a minimum of two databases from inception to January 2022, using several PICO (population/problem, intervention, comparison, outcome) questions (see **Supplementary material**, available online-only). When framing a PICO question was not considered feasible, questions were answered through an expert-based review to elucidate the ESGE-ESGENA position. Subsequently, each working group appraised the available literature and drafted an initial list of statements.

The consensus among panelists for statements was assessed through an anonymous and iterative Delphi process. A maximum of three voting rounds to reach consensus was set beforehand. Statements were graded with a 5-point Likert scale (1 Strongly disagree, 2 Disagree, 3 Neither agree nor disagree, 4 Agree, 5 Strongly agree) via a web-based platform. Panelists could make open suggestions for each statement using a text box. Before voting, panelists received a preliminary manuscript draft that included the evidence supporting each statement. Panelists were asked to consider clinical benefits and harms for patients and health care systems, costs, quality of the evidence, and the environmental impact. Consensus was defined as ≥ 80 % agreement (the sum of Agree and Strongly agree) on each statement. Statements were deleted or reformulated by the

▶ **Table 1** Reducing the environmental footprint of gastrointestinal (GI) endoscopy.

Background: the environmental impact of GI endoscopy	
▪ GI endoscopy is a resource-intensive activity with a significant yet poorly assessed environmental impact. GI endoscopy is estimated to be the third highest generator of hazardous waste in health care facilities.	
▪ GI endoscopic instruments and supplies are composed of thermoplastic polymers, metals, rubber composites, optical glass, and semiconductor materials. Packaging material typically includes paper, cardboard, and plastic.	
▪ GI endoscopy predominantly uses reusable endoscopes and requires a considerable amount of single-use, plastic-predominant, consumable instruments and supplies.	
▪ There is a need to understand and publicly disclose the exact material composition of GI endoscopic instruments and supplies to estimate their environmental impact.	
Statements: the path towards sustainable GI endoscopy	
Clinical and endoscopic management	
1	ESGE-ESGENA recommend adopting immediate actions to reduce the environmental impact of GI endoscopy.
2	ESGE-ESGENA recommend adherence to guidelines and implementation of audit strategies on the appropriateness of GI endoscopy, to avoid the environmental impact of unnecessary procedures.
3	ESGE-ESGENA recommend a rational use of periprocedural and intraprocedural medication to reduce the environmental impact of GI endoscopy.
4	ESGE-ESGENA recommend using low-waste, less invasive alternatives to endoscopy (e. g., fecal calprotectin, urea breath test, etc.) within the bounds endorsed by evidence-based clinical guidelines.
5	ESGE-ESGENA suggest that digitalization, telemedicine, and efficient clinical pathways may reduce the environmental impact of pre- and post-procedural GI endoscopy-related health care.
6	ESGE-ESGENA suggest that diagnostic strategies that safely reduce the number of samples sent for histological analysis can reduce the environmental impact. This can be achieved via optical diagnosis and adherence to guidelines on the indications for endoscopic tissue sampling.
7	ESGE-ESGENA recommend considering the environmental impact when selecting the appropriate endoscopic technique. The less resource-intensive technique should be favored, provided efficacy and safety are maintained.
8	ESGE-ESGENA recommend a rational use of endoscopic accessories during the procedure.
9	ESGE-ESGENA suggest performing most elective endoscopic procedures on an outpatient basis to avoid overnight hospital stays and hence reduce the environmental impact.
Endoscopy logistics	
10	ESGE-ESGENA recommend applying the principles of sustainable architecture to the design and construction of GI endoscopy units.
11	ESGE-ESGENA suggest implementing an accreditation process for GI endoscopy units that embraces sustainability.
12	ESGE-ESGENA recommend favoring the use of renewable energy at GI endoscopy units. This goal should be achieved in the context of local and national policies.
13	ESGE-ESGENA recommend the embedding of reduce, reuse, and recycle programs in the GI endoscopy unit.
14	ESGE-ESGENA recommend revisiting waste management in the GI endoscopy unit to ensure adequate segregation and processing policies. The 3 R (Reduce-Reuse-Recycle) and circular economy principles should be the core of these policies.
15	ESGE-ESGENA recommend the digitalization of the GI endoscopy unit (including electronic reporting), minimizing paper printing, and using energy-efficient endoscopy and electronic devices.
16	ESGE-ESGENA recommend establishing local protocols and environmental educational programs for personnel to practice in an environmentally friendly and sustainable way.
Single-use accessories	
17	ESGE-ESGENA recommend that future clinical guidelines and regulations on GI endoscopy reprocessing/disinfection should consider the environmental impact of these practices and that of single-use devices.
18	ESGE-ESGENA suggest that there is an urgent need to reassess and reduce the environmental and economic impact of single-use GI endoscopic devices. GI and endoscopy societies should collaborate with industry to minimize the environmental burden of single-use devices.
19	ESGE-ESGENA suggest using GI endoscopy devices that have an environmentally sustainable design (e. g., reloadable clips or band ligators).

Single-use endoscopes	
20	ESGE-ESGENA suggest against routine use of single-use GI endoscopes. However, their use could be considered in highly selected patients, on a case-by-case basis.
Education and training	
21	ESGE-ESGENA recommend embedding sustainability into the curricula of GI endoscopy.
22	ESGE-ESGENA recommend conducting research into the environmental impact of GI endoscopy training. Waste reduction and awareness of the environmental costs during training are ethically linked to the notion of high quality GI endoscopy.
23	ESGE-ESGENA recommend that GI endoscopy training should be undertaken in structured, auditable programs and take into account local availability of endoscopy simulators and on-site/off-site teaching modules. Adoption of teaching strategies that shorten the learning curve and ensure safe and efficient procedures is essential to reduce unnecessary waste during training.
24	ESGE-ESGENA suggest that virtual training and online educational modalities can reduce the environmental impact of GI endoscopy.
Green quality	
25	ESGE-ESGENA suggest that the implementation of and adherence to quality measures for GI endoscopy can reduce its environmental impact.
26	ESGE-ESGENA recommend including sustainability as a quality domain for GI endoscopy.
Green research and guidelines	
27	ESGE-ESGENA should encourage and fund research into "green and sustainable" GI endoscopy.
28	ESGE-ESGENA recommend conducting high quality research to quantify and minimize the environmental impact of GI endoscopy.
29	ESGE-ESGENA recommend incorporating the principles of sustainability into every GI endoscopy research project. The study design should consider the environmental impact of the research.
30	ESGE-ESGENA recommend taking into account environmental impact when grading the strength of recommendations in GI endoscopy guidelines.
31	ESGE-ESGENA suggest defining specific PICO (population/problem, intervention, comparison, outcome) questions to evaluate the environmental impact of guideline recommendations. In the absence of evidence, ESGE-ESGENA recommend highlighting the need for research to examine the environmental impact of the GI endoscopy guideline.
Industry, health insurers, and health care providers	
32	ESGE-ESGENA recommend that GI endoscopy companies assess, disclose, and audit the environmental impact of their value chain.
33	ESGE-ESGENA recommend that GI endoscopy companies manufacture environmentally friendly materials and devices.
34	ESGE-ESGENA recommend against planned obsolescence of GI endoscopy materials and devices.
35	ESGE-ESGENA recommend that governments, health insurers, and health care providers align with environmentally preferable purchasing strategies ("green purchasing"), including choosing materials and supplies with a low carbon footprint.
Policymakers, governments, and patients	
36	ESGE-ESGENA recommend that policymakers and governments take immediate action in the path towards environmentally sustainable GI endoscopy.
37	ESGE-ESGENA recommend development of "Choosing Wisely" campaigns for GI endoscopy, discouraging overuse and overtreatment, and thus contributing to lower waste related to GI endoscopy, together with patients and patient organizations.
38	ESGE-ESGENA suggest that patient empowerment programs and a healthy lifestyle can reduce the need for GI endoscopy procedures in the long term.
Conclusion	
39	ESGE-ESGENA recommend that GI endoscopy should become a net-zero greenhouse gas emissions practice by 2050.

ESGE, European Society of Gastrointestinal Endoscopy; ESGENA: European Society of Gastroenterology and Endoscopy Nurses and Associates; GI, gastrointestinal; PICO, population/problem, intervention, comparison, and outcome.

project leaders for the subsequent voting round if the agreement was < 80 %, and considering the suggestions made by the panelists. The results of each voting round are detailed in **Supplementary material**.

After two voting rounds, the final statements (▶**Table 1**) and manuscript were discussed and approved during a second virtual meeting held on 1 April, 2022. This draft was then sent for modifications and final approval to the ESGE Governing Board. Further details on the methodology of ESGE position statements can be obtained elsewhere [7].

A glossary with ten core terms adapted from the IPCC [2] and other sources [8–16] is provided in ▶**Table 2**.

▶ **Table 2** "Green" glossary of core terms.

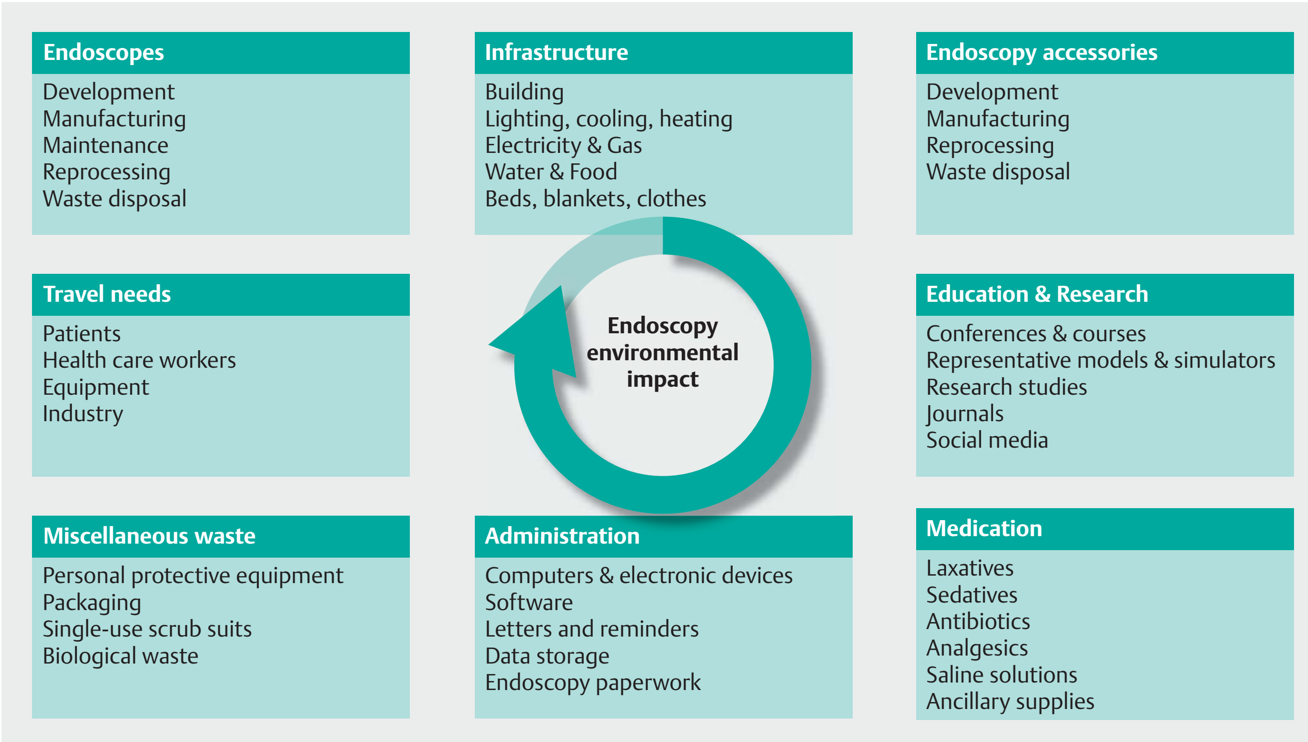
3 R principle (Reduce–Reuse–Recycle)	Sequence of steps on how to manage waste and materials properly. The top priority is Reduce waste and products generation, then Reuse, and then Recycle [8].
carbon footprint	The total set of greenhouse gas emissions caused directly and indirectly by an individual, event, organization, or product [9].
circular economy	A model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible. In this way, the life cycle of products is extended. In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible. This differs from the traditional, linear economic model, which is based on a take-make-consume-throw away pattern [10].
climate change	A variation in the state of the weather and temperatures that persists for an extended period. It may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use [11]. The scientific community agrees that the current climate change is driven by human activities [2].
energy efficiency	The ratio of output of useful energy or energy services or other useful physical outputs obtained, from a system, conversion process, transmission or storage activity, to the input of energy [11].
"green endoscopy"	Term initially used by Maurice et al. [12] that refers to the practice of gastrointestinal endoscopy that aims to raise awareness, assess and reduce endoscopy´s environmental impact. "Green Endoscopy" also refers to an international network of health care professionals that advocates for sustainable practice in endoscopy and related specialties [13].
greenhouse gases (GHGs)	Those gaseous constituents of the atmosphere that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and ozone are the primary greenhouse gases [11].
life cycle assessment	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product or service throughout its life cycle. A full life cycle includes all phases from development of a product, manufacturing, and use, to disposal ("cradle to grave"). This definition builds from International Organization for Standardization (ISO) (2018) [11].
net zero emissions	These are achieved when anthropogenic emissions of greenhouse gases are balanced by anthropogenic removals over a specified period. Based on the Greenhouse Gas Protocol to measure and standardize greenhouse gas emissions [14], three areas ("scopes") contribute to emissions and need to reach net zero to reach full carbon neutrality. Scope 1 represents emissions directly emanating from health care facilities (e. g. anesthetic gases or burning of fossil fuel). Scope 2 represents indirect emissions purchased for electricity or heating/cooling from nonrenewable energy sources. Scope 3 represents emissions originating from the health care supply chain. Within the health care sector, scopes 1, 2, and 3 make up 17 %, 12 %, and 71 % of emissions, respectively [15].
sustainability	A dynamic process that guarantees the persistence of natural and human systems in an equitable manner. Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs, and balances social, economic and environmental concerns [11]. Principles of sustainable health care include patient empowerment, prevention, lean services, and low carbon alternatives [16].

3 The environmental impact of GI endoscopy

3.1 The carbon footprint of GI endoscopy

Health care activities have a substantial carbon footprint, accounting for about 1 % to 5 % of human environmental impact and about 4.4 % of GHG emissions worldwide [5]. The major contributors are generation and distribution of energy, including gas and heat or cooling (40 %), and emissions directly from health care institutions (13 %). Transport (7 %), pharmaceutical and chemical products (5 %) and waste management (3 %) also have a considerable environmental burden [15]. The United States, China, and the European Union (EU) account for more than half of all emissions. If the health care sector were a country, it would be the fifth-largest emitter worldwide [15]. Trend analyses show that health care GHG emissions have increased by nearly a third over the last two decades [5], both in low and high income countries [17]. Notably, several reports indicate that this carbon footprint is largely avoidable and could be reduced without compromising quality [5, 15, 18, 19].

GI endoscopy has direct and indirect ecological harms (▶ **Fig. 1**) and is estimated to be the third highest generator of hazardous waste in health care facilities (3.09 kg/day/bed) [19]. Specific data addressing its environmental impact are very scarce. Furthermore, available data are based on indirect estimates, heterogeneous assumptions, and calculators not designed explicitly for GI endoscopy. The reason for this lack of data is multifactorial and includes a lack of interest from manufacturers, health care providers, and researchers, as well as difficulties in conducting comprehensive life cycle assessment (i. e., lack of methodological consensus and limited data about the origin, manufacturing, and waste disposal of GI endoscopy products) [20]. A summary of available data with current estimates is provided in ▶ **Table 3** [6, 21–24].



▶ **Fig. 1** The environmental impact of gastrointestinal (GI) endoscopy.

BACKGROUND

- GI endoscopy is a resource-intensive activity with a significant yet poorly assessed environmental impact. GI endoscopy is estimated to be the third highest generator of hazardous waste in health care facilities.
- GI endoscopic instruments and supplies are composed of thermoplastic polymers, metals, rubber composites, optical glass, and semiconductor materials. Packaging material typically includes paper, cardboard, and plastic.
- GI endoscopy predominantly uses reusable endoscopes and requires a considerable amount of single-use, plastic-predominant, consumable instruments and supplies.
- There is a need to understand and publicly disclose the exact material composition of GI endoscopic instruments and supplies to estimate their environmental impact.

3.2 Materials used in GI endoscopes and accessories

The literature search revealed that only very limited information is available on the type and amount of materials used in GI endoscopy. Available information includes personal reviews of instruments and supplies and discussion with engineering departments and company representatives [25, 26]. Based on different aspects (structure, properties, processing, and performance), materials used in medical device manufacturing can be classified into polymers, metals, ceramics, composites, and biomaterials. Polymers are large molecules made by chemical linking of repeating units (forming thermoplastics, thermosets, and elastomers), to provide various forms of rubber and plastics. Metals are commonly used because of their strength, toughness, durability, and high electrical and thermal conductivity. These include stainless steel, aluminum, brass, copper, nickel, and titanium. Ceramics are robust inorganic and nonmetallic materials, including glass and other crystalline structures with piezoelectric properties. Composite materials combine two or more of the aforementioned groups [27]. For example, the alloy nitinol (nickel and titanium) is used in self-expandable metal stents. Finally, biomaterials are nonvital materials intended to interact with biological systems to replace or restore functions [27, 28]. In addition, packaging contributes considerably to total materials used, and typically includes plastic, paper, and cardboard.

Details of the material composition of reusable or single-use GI endoscopic instruments are not publicly available. The major components of GI reusable endoscopes are metal (approximately 70 % of total mass) and plastic (25 %–30 %), with a remaining small proportion of electronic components. In contrast, single-use GI endoscopes consist primarily of plastic and a lesser proportion of metal. Accessory devices (e. g., water bottles, irrigation tubes, polyp snares, etc.) are generally plastic-predominant [6]. Plastics used in GI endoscopy include some with potential carcinogenic and adverse effects on health such as polyvinyl chloride (PVC) and phthalates, and hence

▶ **Table 3** Estimates of the environmental impact of gastrointestinal (GI) endoscopy.

First author	Methodology and topic	Estimates
Gayam [21]	Cross-sectional study on endoscopy waste and carbon footprint using online calculators. See Supplementary material for methodology. It does not include pre- and post-procedure care. Carbon footprint does not include manufacturing, distribution, disposal, heating, or facility energy needs.	▪ One endoscopic procedure: 1.5 kg of waste (0.3 % kg recyclable). ▪ 1-year endoscopy activity in the United States (18 million procedures): – 13 500 tons of plastic waste, of which 10 800 tons are non-recyclable. – CO2 emissions equivalent to more than 3 995 448 gallons of gasoline consumed. ▪ Energy consumption per day in a GI endoscopy unit located in the United States that averages 40 procedures per day: – Wash machines 24.67 kWh – Endoscopy machines 27.00 kWh – Anesthesia machine 12.00 kWh – Room lighting 47.88 kWh – Total 111.55 kWh.
Namburar [22]	Cross-sectional study of endoscopy waste at 2 academic centers in the United States, including pre- and post-procedure care.	▪ One endoscopic procedure: 2.1 kg of disposable waste (46 L); 64 % of waste went to landfill, 28 % was biohazard waste, and 9 % was recycled. Personal protective equipment accounted for 8 % of waste. ▪ 1-year endoscopy activity in the United States: 38 000 metric tons of waste (equivalent to 25 000 passenger cars). ▪ Universal single-use endoscopes would increase the net waste mass by 40 %.
Siau [6]	Narrative review on endoscopic procedure and transport	▪ 1-year endoscopy activity in the United States (18 million procedures): 85 768 tonnes of CO2 → 4.8 kg of CO2 per endoscopy. This calculation includes CO2 related to waste and basic energy needs. ▪ The carbon footprint of a GI scientist using an electric vehicle and accounting for conference travel has been estimated at equivalent to 20.8 tonnes of CO2 per year.
Gordon [23]	Life cycle assessment of pathology specimen	▪ Equivalent to 0.28 kg CO_2 per GI biopsy when 1 jar is used and 0.79 kg CO_2 when 3 jars are used; emissions equivalent to driving a typical passenger vehicle 0.7 mile and 2.0 miles, respectively. ▪ Production of supplies was the largest contributor to greenhouse gas emissions.
Hernández [24]	Life cycle assessment of single-use duodenoscope Only presented as a conference abstract	▪ Single-use duodenoscope consumes 467 MJ and releases 29.3 kg of CO_2 ▪ Reusable duodenoscope 26.8 MJ and 1.55 kg CO2; 20 times less than single-use model. ▪ Duodenoscope with disposable end caps 23.4 MJ and 1.37 kg CO_2.
Vaccari [19]	Data on per capita health care spent at the national level, as well as a case study of a hospital in Italy	▪ Departments with highest generation of hazardous waste per daily occupied bed were: 1 anesthetics, 2 pediatric and intensive care, and 3 gastroenterology–digestive endoscopy (3.09 kg/day/bed). ▪ Departments with the highest average monthly waste generation rates per clinical procedure were 1 radiology (0.67 kg/procedure), 2 gastroenterology–digestive endoscopy (0.50 kg/procedure), and 3 plastic surgery.

some companies are moving towards a PVC-free policy [29]. A shift towards recyclable and environmentally friendly GI endoscopy materials is of paramount importance.

Regarding the nature of materials, there is minimal information from manufacturers. Unfortunately, current EU regulations on medical devices do not force companies to publicly detail the composition and sources of materials used in GI endoscopy devices, and this information is rarely provided to users [30]. Knowing the type of material used is key to estimating the environmental impact of GI endoscopes and devices. A life cycle assessment requires data on how materials were resourced and used in the manufacturing process. In addition, material type determines its potential for reuse, for recycling (for instance, thermoplastics can be recycled, but thermoset plastics cannot), or for incineration and determines the time to decomposition in a landfill [6].

4 The path towards environmentally sustainable GI endoscopy (▶ Fig. 2)

STATEMENT

1 ESGE-ESGENA recommend adopting immediate actions to reduce the environmental impact of GI endoscopy.

4.1 Reducing the carbon footprint before, during, and after GI endoscopy

In our systematic search, we did not find any study that directly evaluated the impact on environmental outcomes of GI endoscopy or related clinical management (see **Supplementary material**).

4.1.1 Clinical management

STATEMENT

2 ESGE-ESGENA recommend adherence to guidelines and implementation of audit strategies on the appropriateness of GI endoscopy, to avoid the environmental impact of unnecessary procedures.

STATEMENT

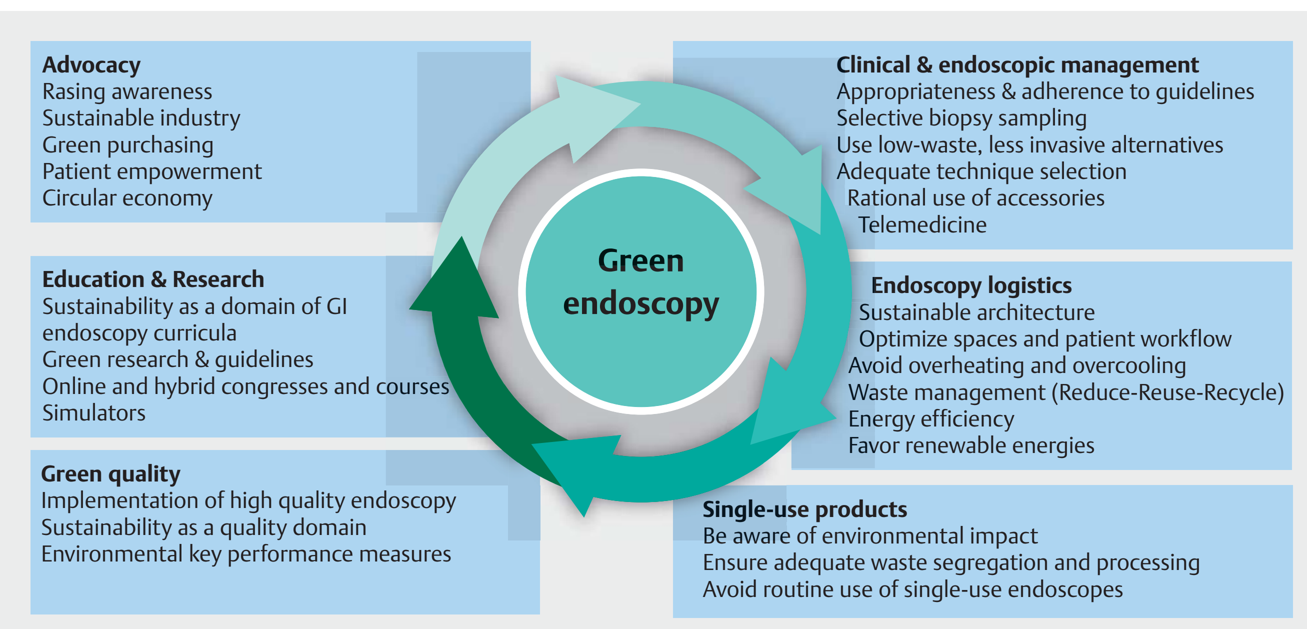
3 ESGE-ESGENA recommend a rational use of periprocedural and intraprocedural medication to reduce the environmental impact of GI endoscopy.

Several actions beyond the endoscopic procedure itself are of paramount importance to reduce the carbon footprint.

ESGE-ESGENA consider that reducing the current rate of unnecessary GI endoscopic procedures is key to that end and should be prioritized by GI endoscopy services and health care systems. This is probably the most effective action to mitigate the GHG emissions of GI endoscopy.

Adherence to guidelines ensuring the appropriateness of the indication for GI endoscopy is vital to optimizing patient care and use of resources [31, 32]. Triage of waiting lists and cancellation of unnecessary procedures have proven useful during the COVID-19 pandemic and deserve to be evaluated in the long term [33–35]. Two recent meta-analyses indicate that the rate of inappropriate upper GI endoscopies and colonoscopies is 20 %–30 % [36, 37]. Limiting endoscopic procedures to only those that are appropriate has been shown to be cost-effective, reduces procedure-related risks, and significantly increases the probability of diagnosing relevant findings, including malignancy [36]. Nevertheless, appropriateness criteria are not perfect and should always be combined with clinical judgment [31, 32].

Oversurveillance is also common and has been extensively documented in several conditions such as Barrett's esophagus [38] or colonic polyps [39]. In this regard, ESGE has published a document to summarize when endoscopic follow-up is not recommended [32]. Recent guidelines are expected to reduce surveillance colonoscopies by over 80 %, with notable cost savings and capacity improvements [40]. Endoscopy services are encouraged to assess the appropriateness of endoscopy and to take action when endoscopy has been performed inappropriately [41]. Avoiding routine pre-endoscopy testing (e. g., blood tests, electrocardiography, or chest radiography) can additionally reduce the carbon footprint [42].



▶ **Fig. 2** The path towards sustainable endoscopy.

Medications before endoscopy (e. g. bowel preparation and laxatives for colonoscopy, or mucolytic solutions before esophagogastroduodenoscopy), during (e. g. sedatives, antibiotics, or analgesics), and after the procedure also have also an environmental burden that has not been formally quantified [43]. It has recently been estimated that 1 g medication has a CO_2 footprint of somewhere between 10 g and 1000 g, compared to 1 g of oil, which has a 3-g CO_2 footprint [44]. Thus, the use of medication only when strictly indicated is a simple and ethical green measure (e. g. avoiding routine saline fluid intravenous solution during sedation, inadequate antibiotic prophylaxis, etc.) [43].

Direct environmental impact comparisons between nitrous oxide and intravenous sedation strategies specifically in the context of endoscopy have not been published. Nonetheless, nitrous oxide has a global warming potential of nearly 300 times that of CO_2 [45], and its negative environmental impact is well recognized in the anesthesiology community, where significant efforts to minimize its use are underway [46]. Moderate versus deep sedation versus endotracheal intubation, and selective versus universal involvement of an anesthesiologist, are factors that may influence the GI endoscopy carbon footprint and deserve future assessment.

STATEMENT

4 ESGE-ESGENA recommend using low-waste, less invasive alternatives to endoscopy (e. g. fecal calprotectin, urea breath test, etc.) within the bounds endorsed by evidence-based clinical guidelines.

Intuitively, using low-waste less invasive alternatives to GI endoscopy is another sensible approach to limit environmental impact [47]. However, manufacturers do not disclose the ecological footprint of less invasive tests and we lack comparative life cycle assessment studies between these alternative tests and GI endoscopy. Thus, the benefits of this strategy in all scenarios should not be entirely assumed, especially for high-tech less invasive tests that require intense manufacturing and processing. Until further data are available, ESGE-ESGENA encourage less invasive tests for the indications endorsed by evidence-based clinical guidelines (▶ **Table 4** [48–56]).

STATEMENT

5 ESGE-ESGENA suggest that digitalization, telemedicine, and efficient clinical pathways may reduce the environmental impact of pre- and post-procedural GI endoscopy-related health care.

The current COVID-19 crisis has placed telemedicine as a necessary alternative to face-to-face medical consultations with promising results [57], thereby decreasing direct and indirect contributions to the environmental footprint of health care [58]. Although there is no direct evidence, reasonable estimations from a systematic review suggest that telemedicine reduces the carbon footprint of health care, mainly by lowering transport-associated GHG emissions [59]. The environmental cost of telemedicine equipment was also assessed and was comparatively low.

Telemedicine has great potential to reduce in-person visits related to low-risk procedures or visits intended to communicate GI endoscopy results that do not substantially impact clinical management. However, the efficiency of telemedicine is context-dependent and some patients express an unwillingness to abandon face-to-face medical consultations [57].

Similarly to the strategies explored in GI endoscopy workflow improvement, specific local situations (including infrastructure and patient preferences) should be analyzed to identify actionable factors. The benefits and applicability of telemedicine require more study to assuage fears of misdiagnosis or of uncertainty, leading to the risk of double consultations.

4.1.2 Endoscopic intraprocedural management

The specific intraprocedural factors that determine GI endoscopy's environmental impact include the use of a high volume of single-use consumables, energy and water usage, medications, and tissue sampling requiring histological analysis (▶ **Fig. 3**).

STATEMENT

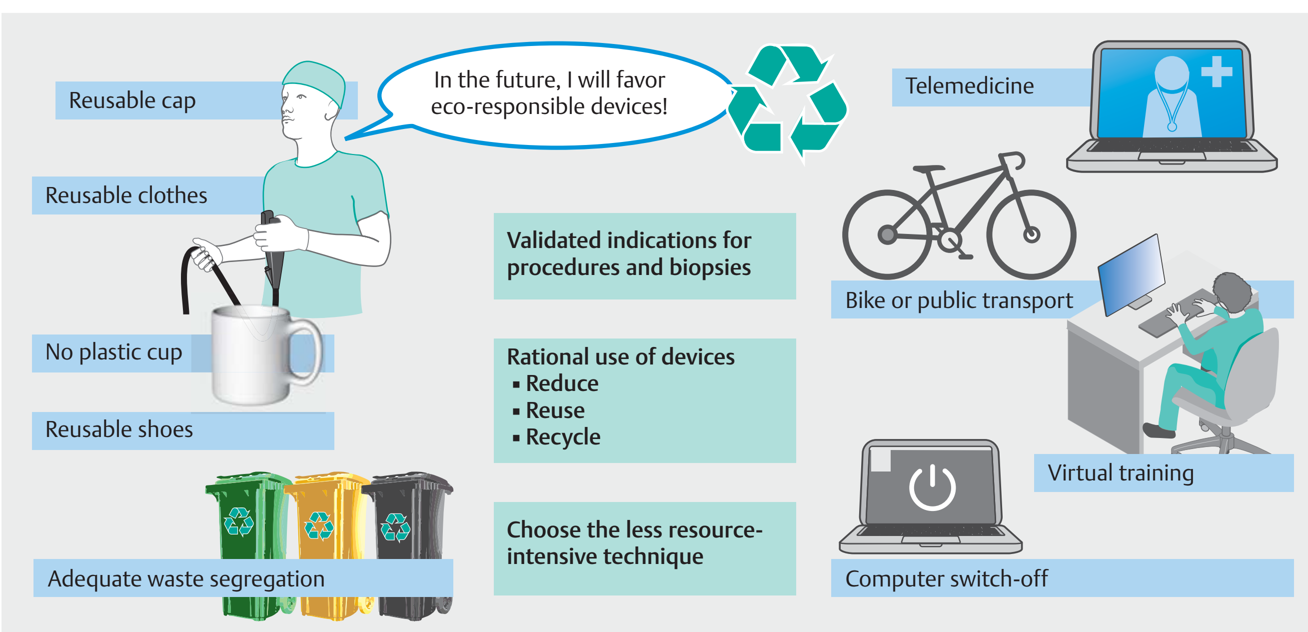
6 ESGE-ESGENA suggest that diagnostic strategies that safely reduce the number of samples sent for histological analysis can reduce the environmental impact. This can be achieved via optical diagnosis and adherence to guidelines on the indications for endoscopic tissue sampling.

The processing of biopsies entails an added energy requirement, generates hazardous waste and is responsible for a significant carbon footprint which increases roughly proportionally to the number of biopsy specimen bottles sent for histological analysis [23]. Endoscopy's histopathological output can be reduced without altering the management of most patients by ensuring that only appropriate biopsies are undertaken [60, 61]. Adherence to such guidelines, along with strategies that safely avoid the need for histological analysis, would likely reduce endoscopy's carbon footprint.

Optical diagnosis is used for mucosal lesions throughout the GI tract, and is integral to diagnose-and-leave and resect-and-discard strategies for managing diminutive colorectal polyps [62]. Both these strategies reduce the number of tissue samples sent for analysis and thereby endoscopy's carbon footprint. ESGE has endorsed the use of optical diagnosis in place of histopathology for diminutive colorectal polyps, under strictly controlled conditions [63], and has subsequently published a curriculum to develop and maintain these relevant skills [64]. While a resect-and-discard strategy is referenced in British guidelines [65], and the findings of a meta-analysis [66] confirm fulfillment of American Society of Gastrointestinal Endoscopy (ASGE) minimum performance thresholds for imaging technologies [67], the practice of these strategies has yet to

▶ **Table 4** Less invasive tests approved by regulatory agencies as alternatives to gastrointestinal endoscopy.

Less invasive test	Indication endorsed by guidelines	Research
Fecal immunohistochemical testing [48]	Colorectal cancer screening Triage of symptomatic patients in primary health care	Postpolypectomy surveillance in high risk individuals Iron-deficiency anemia Colorectal cancer prognosis Endoscopy waiting list triage
Multitarget DNA stool test	Colorectal cancer screening	Postpolypectomy surveillance
Fecal calprotectin [49, 50]	Chronic diarrhea Monitoring patients with inflammatory bowel disease	Biomarker in other inflammatory diseases Protein-losing enteropathy
Urea breath test [51] Stool antigen test [51]	Diagnosis and eradication of *Helicobacter pylori*	
Cytosponge [52]	None	Barrett's esophagus Eosinophilic esophagitis
Elastography and platelet count [53]	Screening of esophageal varices in cirrhosis Monitoring liver disease	Noninvasive diagnosis and prognosis of liver disease
Small-bowel capsule [54]	Obscure gastrointestinal bleeding Iron-deficiency anemia Inflammatory bowel disease workup Refractory celiac disease	Monitoring mucosal healing in Crohn's disease
Esophageal and colon capsules [55]	None	Upper gastrointestinal symptoms and bleeding Detection of esophagitis and varices Colorectal cancer screening Postpolypectomy surveillance Incomplete colonoscopy
Transnasal unsedated endoscopy [56]	None	Barrett's esophagus Eosinophilic esophagitis Variceal screening Gastric cancer



▶ **Fig. 3** The "eco-endoscopist."

be widely implemented in those countries. Medicolegal concerns, lack of awareness, financial incentives, and patient acceptability are some of the hurdles to their widespread implementation. Substitutes for histopathological analysis will likely expand further with both the evolving indications for endoscopic optical diagnosis, such as in the diagnosis of celiac disease [68], and the growing use of artificial intelligence (AI) systems.

STATEMENT
7 ESGE-ESGENA recommend considering the environmental impact when selecting the appropriate endoscopic technique. The less resource-intensive technique should be favored, provided efficacy and safety are maintained.

STATEMENT
8 ESGE-ESGENA recommend a rational use of endoscopic accessories during the procedure.

STATEMENT
9 ESGE-ESGENA suggest performing most elective endoscopic procedures on an outpatient basis to avoid overnight hospital stays and hence reduce the environmental impact.

Judicious and rational use of GI endoscopic techniques and accessories is also crucial to achieving sustainable practice. In this context, less resource-intensive techniques should be favored, provided efficacy and safety are maintained and their use is supported by current evidence-based clinical guidelines. Thus, ESGE-ESGENA encourage appropriate technique selection to avoid the overuse of procedures that may involve a greater consumption of resources, such as cholangioscopy, endoscopic suturing, full-thickness resection, or endoscopic submucosal dissection (ESD). This strategy should be balanced with the GIRFT ("getting it right first time") principle that aims to reduce the number of therapeutic procedures that are unnecessarily repeated because a definitive outcome is not achieved in the initial intervention. These concepts extend not only to GI endoscopists but to the whole health care chain, including well-informed patients.

Regarding accessories, in clinical practice prophylactic clipping of polyp resection defects does not always adhere to current recommendations and its overuse should be discouraged [69]. In this sense, determining the average need of accessories per procedure and periodically revisiting the number of accessories used could help to reduce waste and gain efficiency. Favoring cold snare polypectomy and underwater endoscopic mucosal resection (EMR) in validated indications could reduce the procedural carbon footprint. Cold snare polypectomy avoids the use of an electrosurgical unit and a disposable electrode pad. Underwater EMR avoids the use of an injection needle, a syringe, and submucosal solution, as well as the packaging of all these accessories. There is currently little published experience on the reuse of GI endoscopy accessories (e.g., injection needle, biopsy forceps, polypectomy snare, etc.) within the same or combined procedures (e.g., gastroscopy followed by colonoscopy). In the absence of safety or efficacy concerns, prioritizing the reuse of GI endoscopy accessories within a single procedure should be encouraged (e.g., using the same polyp snare for the resection of small polyps or the same biopsy forceps for duodenal and gastric biopsies).

The use of sterile or potable tap water in irrigation bottles is a matter of ongoing debate and has environmental and financial relevance. The rationale for the use of sterile water is that the concentration of pathogenic microorganisms in tap water may exceed the infectious dose and thus cause disease. A recent multisociety guideline and ESGE-ESGENA guidelines recommend using sterile water following manufacturers' instructions, based on low quality evidence [70, 71]. In the absence of a manufacturer's recommendation, the endoscopy unit should perform an independent risk assessment for using sterile versus clean tap water for standard endoscopic procedures in which mucosal penetration would be unusual [70]. Given the concern regarding infection in selected patients, this multisociety guideline suggests that sterile water should be the primary water source, especially for those procedures with anticipated traversing of GI mucosa [70]. Conversely, some authors advocate using potable tap water because most microorganisms in tap water are nonpathogenic and do not cause disease except in unusual circumstances [72]. Outside endoscopy practice, randomized controlled trials (RCTs) have shown no difference between the use of tap water and saline in the rates of infection and healing in the cleansing of wounds [73]. In addition, the exposure of the nonsterile GI lumen to potential pathogens would theoretically be the same when water is ingested before or after the GI endoscopic procedure. Furthermore, two studies support the idea that using tap water is safe and found that the rate of positive water cultures was similar to that of sterile water [74, 75]. The only published reports on transmission of infection by water identified unsterilized irrigation water bottles as a source of infection [72]. Underwater EMR and water-exchange colonoscopy have been performed using clean tap water without any safety concerns [76, 77], although the type of water has not been formally compared in any study and was overlooked in a recent international consensus study [78]. Finally, there are no direct data showing that the use of potable tap water increases the risk of infection for patients. Thus, the idea of a universal need for sterile water deserves to be revisited and future guidelines should weigh clinically relevant infection risks, costs, and environmental concerns.

Finally, most elective GI endoscopic procedures should be performed on an outpatient basis, as hospitalization for a procedure incurs more resource consumption and CO_2 emissions [79]. Several reports support that well-selected high risk procedures, including ESD [80], peroral endoscopic myotomy [81], or endoscopic retrograde cholangiopancreatography (ERCP) [82] can be performed safely without hospitalization. Comorbidity, risks of the procedure, and accessibility to health care in case of an adverse event should be considered when deciding the need for admission.

4.2 Endoscopy logistics: a sustainable structure and functioning of the GI endoscopy unit

STATEMENT
10 ESGE-ESGENA recommend applying the principles of sustainable architecture to the design and construction of GI endoscopy units.

STATEMENT
11 ESGE-ESGENA suggest implementing an accreditation process for GI endoscopy units that embraces sustainability.

STATEMENT
12 ESGE-ESGENA recommend favoring the use of renewable energy at GI endoscopy units. This goal should be achieved in the context of local and national policies.

No studies have assessed the most efficient and sustainable structure of a GI endoscopy unit. However, some data are available from studies on carbon footprint reduction in the operating room [83–85]. The design and the functioning of the endoscopy unit as proposed by current guidelines do not consider the issue of sustainability [71, 86, 87]. ESGE-ESGENA advocate incorporating the principles of sustainable architecture and efficient energy management at every step of this process and suggest implementing an accreditation process for GI endoscopy units that includes sustainability [88–91]:

- **Location.** There are no studies comparing the environmental impact of hospital-based versus out-of-hospital GI endoscopy units. Location should take into account local needs (e. g., low risk versus high risk procedures, number of procedures, etc.) and legislation, population density, costs, adaptability to changing climate conditions, and local biodiversity. The endoscopy unit should be easily accessible by public transportation and located in proximity to patients to minimize travel needs.
- **Use of sustainable, long-life, and nontoxic building materials.**
- **Heating, cooling, and ventilation.** Overcooling and overheating are responsible for billions of tons of CO_2 emissions worldwide [92]. The optimal temperature and humidity of the endoscopy room have not been established [93]. Local protocols and use of sensors should aim at maintaining a temperature that takes into account infection control, patient and provider comfort, and energy demands.
- **Use of renewable energy sources.** It has been estimated that 10 %–30 % of the environmental impact related to an operating room-based surgery comes from electricity consumption [94]. Promoting renewable energy at an institutional level should be prioritized.
- **Efficient workflow and use of space.** This concept includes a structure that assures an optimal flow of patients, endoscopy unit personnel, and supplies; and avoids empty, unused, spaces. Endoscopy rooms that are not in use should be put into a “sleep” mode to conserve energy, and a plan for better use of this space implemented. An optimal workflow is crucial for optimizing the efficiency of the endoscopy unit. The following measures can improve efficiency: having dedicated staff for performing intravenous access and for obtaining informed consent before the patient enters the endoscopy room; utilization of block scheduling; minimizing room turnover times; fluent communication among staff; and consideration before scheduling of the types of sedation to be administered [95]. Instead of morning-only activity, morning and evening shifts have been adopted by several GI endoscopy units, and this seems to be a reasonable strategy to cope with the growing demand for GI endoscopy without increasing the number of endoscopy rooms [96]. A meta-analysis suggests that colonoscopy quality is not affected by the time of the day, provided that endoscopists do not perform full-day shifts [97].
- **Efficient use of natural resources.** The unit should incorporate natural light in most rooms as much as possible. Water efficiency is paramount and can be achieved via low water consumption equipment for disinfection and reprocessing, efficient laundry, and low-flow toilets in patient spaces [91].

STATEMENT
13 ESGE-ESGENA recommend the embedding of reduce, reuse, and recycle programs in the GI endoscopy unit.

STATEMENT
14 ESGE-ESGENA recommend revisiting waste management in the GI endosopy unit to ensure adequate segregation and processing policies. The 3 R (Reduce-Reuse-Recycle) and circular economy principles should be the core of these policies.

STATEMENT
15 ESGE-ESGENA recommend the digitalization of the GI endoscopy unit (including electronic reporting), minimizing paper printing, and using energy-efficient endoscopy and electronic devices.

STATEMENT
16 ESGE-ESGENA recommend establishing local protocols and environmental educational programs for personnel to practice in an environmentally friendly and sustainable way.

- **Waste management.** The majority of health care waste (approximately 85 %) is nonhazardous and similar to domestic waste, which means that much of it could be recycled [98, 99]. Poor medical waste management has a deleterious economic and ecological impact [19, 22, 100]. GI endoscopy waste is often handled inappropriately [101], and materials and packaging are rarely recycled [19, 22, 100]. Placing labels on waste containers to facilitate segregation and incorporating recycling bins in the GI endoscopy unit are actions that can be easily implemented.
  In a survey of 783 GI endoscopy staff members, only 0.6 % understood waste disposal costs, over a third disposed waste inappropriately, and 98 % felt that medical personnel should be better informed about medical waste management [101]. Consequently, adequate waste segregation and revisiting institutional waste management policies are integral to the concept of green GI endoscopy.
  The guiding principles for future sustainable health care waste management include: application of the 3Rs (Reduce–Reuse–Recycle) (▶ **Table 2**); phasing down incineration; ensuring toxicity-free waste; ensuring worker protection; implementing circular economy principles; and ultimately achieving zero waste (▶ **Fig. 2**) [98, 99]. Further details on sustainable health care waste management can be found elsewhere [98, 99].
- **Disinfection and reprocessing.** There is a need to examine the environmental impact of our reprocessing processes and to implement sustainable practice. This includes efficient energy and water use in washer-disinfectors and using process chemicals that have an environmentally friendly value [71].
- **Digitalization.** The digitalization of GI endoscopy-related health care data, reports, and patient letters can benefit the environment [102]. ESGE-ESGENA recommend minimizing use of paper, printing double-sided if printing is needed, and using paper products that are made from recycled material and nonbleached (chlorine bleach releases toxic dioxins into water). Use of 100 % recycled paper is claimed to reduce GHG emissions by 37 % and water use by 50 % [103].
- **Energy efficiency of electronic devices.** This includes GI endoscopy systems and all electronic devices in the unit (computers, monitors, endoscope reprocessors, etc.). Room lighting can consume more energy than endoscopy itself [21]. Thus, LED lighting or energy-saving light bulbs should be preferred. Energy consumption is lessened by switching lights off, and turning off computers (or placing them in “sleep” mode) and also printers, coffee machines, etc., during extended breaks and at the end of the day [21, 104].
  Units should consider installing motion sensors to switch off lights. Automatic control of lighting using daylight-dimming and occupancy sensors leads to major energy savings [105].
- **Staff education.** Implementation of sustainable endoscopy practice requires GI endoscopy team members to re-examine their habits, modify them if needed, and become educated about the abovementioned aspects. Members of the endoscopy team can further contribute outside the endoscopy unit by using public transportation to get to work. Making a public commitment towards environmentally sustainable practice in the endoscopy unit in the form of a guidance document sends a clear message to staff, patients, and visitors that the unit cares about the climate crisis, and that all the agents involved in the health care chain can do something about it [90].

4.3 Single-use products

4.3.1 Single-use accessories

STATEMENT
17 ESGE-ESGENA recommend that future clinical guidelines and regulations on GI endoscopy reprocessing/disinfection should consider the environmental impact of these practices and that of single-use devices.

STATEMENT
18 ESGE-ESGENA suggest that there is an urgent need to reassess and reduce the environmental and economic impact of single-use GI endoscopic devices. GI and endoscopy societies should collaborate with industry to minimize the environmental burden of single-use devices.

A “single-use” device is defined as a medical device intended to be used on one individual during a single procedure. The “single-use” label is solely based on the decision of manufacturers [106]. The following GI endoscopy accessories have been marketed as resusable and are still available in some places:
- bougie dilators [107–109]
- biopsy forceps [110–112]
- band ligation devices [113]
- sphincterotomes [114–118]
- baskets for stone retrieval [118, 119]
- reloadable clip applicators [120]
- suction and air valves [121]
- snares, guidewires, and balloon expanders [121]
- personal protective equipment [122].

There has been a shift towards the increasing use of single-use accessories in the last two decades. The environmental impact of this transition in GI endoscopy has not been formally addressed and lacks solid scientific background. Data from the anesthesia community indicate that the widespread use of single-use medical devices in the operating theatre does not significantly reduce patients' risk of infection but has a greater financial, environmental, and social impact than use of reusable devices [123].

Despite the strong recommendation of ESGE-ESGENA guidelines for using single-use endoscopic accessories whenever possible [71], and particularly when the epithelial barrier is penetrated [121], the real risk of infection transmission due to reusable accessories remains controversial [114]. The 2010 ASGE Technology Committee guideline on ERCP cannulation and sphincterotomy devices [124], claims that reprocessed reusable devices offer potential cost savings when available and adequately reprocessed [118]. Several studies support the idea that reusable devices are safe when adequately reprocessed [112, 114–118]. Worldwide, although several infection outbreaks have occurred that were related to duodenoscope reprocessing [125–128], this has never been described with reusable devices. Furthermore, the reuse of surgical instruments has demonstrated a reduction of 10 % of GHG in a surgical study [129].

On the other hand, other studies suggest that the risk of intection is not null [110, 111, 113, 130]. Consideration should also be given to the loss of function of devices after the reprocessing procedure [121]. Also, reprocessing has itself an environmental burden that should be acknowledged.

Reprocessing of single-use devices is forbidden in some but not all EU countries [131]. Current EU legislation mentions that reprocessing of devices should only take place where permitted by national law and mostly with reusable devices. "Reusable" here means tested by the manufacturer with the demonstration that the device ensures an equivalent level of safety and performance to the corresponding initial single-use device [30]. Nevertheless, Regulation (EU) 2017/745 allows member states not to apply all of the rules relating to manufacturers' obligations laid down in that Regulation. One of the conditions for such reprocessing is that it is performed under common specifications. In particular, the reprocessing cycle should be based on the characteristics of the single-use device and the results of a technical assessment.

Recommendations on single-use GI endoscopy reprocessing are beyond the scope of this document. Yet, current clinical guidelines fail to consider sustainability [70, 71, 132]. ESGE-ESGENA recommend that future guidelines and legislation on GI endoscopy reprocessing/disinfection should take this domain into account.

The environmental and economic impact of waste generated by single-use devices is high. Proactive collaboration between endoscopy societies and manufacturers to provide single-use devices more responsibly is needed. For instance, the weight and dimensions of packaging and the amount of material used should be examined. Extensive printed user instructions are no longer justifiable; instructions for use and guarantee documents represent around 30 % of the total weight for some devices, mainly in paper which is not always recycled. A QR code instead of a printed manual for each device is preferable. Creation of an environmental score for each GI endoscopy device based on its life cycle (similar to the Nutri-Score for the nutritional value of food) could be of value in helping to choose the most ecologically desirable devices.

STATEMENT

19 ESGE-ESGENA suggest using GI endoscopy devices that have an environmentally sustainable design (e. g. reloadable clips or band ligators).

The concept of reuse is an integral part of sustainability. Some single-use devices can be reloaded so that the whole device is not entirely disposed of with each use [120]. This is the case with clips that are available in a single-use but reloadable version. The same handle (< 80 g) can be used to reload clips during the same procedure (waste weight between 5 g and 10 g) instead of using a single-use device with a measured waste weight of more than 80 g for each clip. The same principle applies to reloadable esophageal variceal band ligators [120, 133].

4.3.2 Single-use endoscopes

STATEMENT

20 ESGE-ESGENA suggest against routine use of single-use endoscopes. However, their use could be considered in highly selected patients, on a case-by-case basis.

The main arguments in favor of single-use rather than reusable endoscopes have been reduction in the risk of infection and greater cost–effectiveness, from a hospital viewpoint. We reviewed the literature to determine the risk of infection with reusable endoscopes and appraised the available data on single-use endoscopes. Data are limited, heterogeneous, and with potential for both overestimation and underestimation:

1 Endoscopy-related infection. There is no consensus on what constitutes an endoscopy-related infection [126, 134]. The estimated risk ranges from 1 in 20 000 to 1 in 1.8 million procedures [135, 136]. However, some cost–effectiveness analyses of single-use endoscopes have used a much higher figure for risk, which may have led to overestimates of the true cost–effectiveness [137–139]. The risk of a clinically relevant infection is probably very low since multiple steps are needed (i. e., high enough infectious load leading to bacteremia and bypassing the immune system). This is further complicated because some of these conditions may already be present in the patient or inherent to the ERCP and might not impact clinically relevant outcomes. For instance, in an RCT that evaluated the need for antibiotic prophylaxis for endocarditis, the authors reported bacteremia in 23 % of patients after brushing teeth and 60 % after tooth extraction, suggesting that bacteremia is mostly inconsequential [140].

2 Endoscope contamination and infection risk. Using contamination of the endoscope as a surrogate marker for infection risk to patients is fraught with inaccuracies and variability. Most studies have centered around duodenoscopes because of their complex tip design and difficulty in cleaning. Between 2008 and 2018, there were 24 reported clusters of duodenoscope-associated multidrug resistant microorganisms, including 490 infected patients and 32 deaths worldwide [141]. In a subsequent systematic review, the calculated minimum estimated duodenoscope-associated infection risk was 0.01 % and the minimum estimated duodenoscope-associated colonization was 0.023 %–0.029 % [142]. However, a potential risk of infection is inherent with all endoscopies. Ofstead et al. assessed endoscope reprocessing at three hospitals and detected contamination in 71 % of endoscopes [143]. They examined 45 endoscopes, of which only 5 were duodenoscopes. This study suggests that contamination of the endoscope rarely translates into clinical infection.

3 Basis of cost–effectiveness analyses. Available cost–effectiveness analyses are written from a hospital perspective when considering costs related to capital equipment, reprocessing, maintenance, and potential post-endoscopic infections [144]. These analyses assume a high rate of endoscope-related infection (~1 %) and high costs of infection treatment in the intensive care unit [137, 138]. The convenience and low cost of using single-use endoscopes for a hospital should not be conflated with a possible reduction of endoscope-associated infections since the beneficiaries are different.

4 Infection risk and human error. Infection risk is, to a large extent, due to human error during reprocessing. Inadequate reprocessing and nonadherence to protocols have been reported with endoscope-related infections [126]. An international survey identified a large variation in endoscope-reprocessing practices [145]. While infection risk cannot be eliminated entirely with adequate reprocessing, it can be substantially reduced [126]. Standardized education and training programs that include a competency assessment, as well as periodic auditing, and researching more effective methods of endoscope reprocessing have the potential to reduce infection rates even further. Reinforcing the importance of hand hygiene and other basic hygiene measures is crucial, whether or not single-use or reusable endoscopes are employed. These interventions are often overlooked in routine clinical practice and impact the risk of infection [146].

5 Societal impact of single-use endoscopes. It is essential to review the consequences of adopting single-use endoscopes from a societal perspective (economy, environment, and social justice). For example, the cost of a single-use duodenoscope ranges from 1900 to 4000 USD (approximately 1700–3600 EUR) [139, 147], and for all the ERCPs performed, the total additional cost load to health care systems would be billions of euros. This might lead to difficult decisions related to the reallocation of already limited resources, paring of certain medical services, or more financial burden on patients. From an environmental perspective, it is estimated that switching to single-use endoscopes would increase waste by 40 % [22]. The carbon footprint of single-use endoscopes remains to be determined, but it is probably substantial. A recent preliminary study estimated that a single-use duodenoscope consumes 467 MJ and releases 29.3 kg of CO_2, 20 times more than a reusable one or a duodenoscope with disposable end caps (23.4 MJ and 1.37 kg CO_2) [24]. Disposable end caps and sheaths are available for some marketed duodenoscopes and could reduce infection risk, but more data are still needed [148].

6 Benefit for selected patients. It has been proposed that immunocompromised patients or those with multidrug-resistant bacteria are likely to benefit from single-use endoscopes, but the theoretical advantages of this strategy remain to be proven in comparative studies [149]. Available data on single-use endoscopes, mainly duodenoscopes (▶**Table 5**, ▶**Table 6**), comprise cost–effectiveness analyses based on heterogeneous assumptions [137–139] and studies limited to reports of technical feasibility and procedural safety [152, 154, 157–161].

Summary. Thus, the available data indicate that clinically relevant endoscope-related infection risk after adequate endoscope reprocessing is probably minimal, although not zero. The approach to endoscope-related infections needs to follow the principle of ALARP ("as low as reasonably practicable") [162] so that the economic, environmental, and social costs in trying to reduce the risk to zero do not outweigh the benefit gained. A more robust and consensus-driven definition of endoscope-related infection is needed. Data based on life cycle assessments of single-use endoscopes and comparative studies focused on clinically relevant outcomes are mandatory before formal recommendations can be made about their routine use. At present, the employment of single-use endoscopes in highly selected cases might be considered individually. Nevertheless, evidence showing a net benefit is lacking and insufficient to make recommendations.

4.4 Education and training

4.4.1 Incorporating the environmental dimension into curricula and training for GI endoscopy

STATEMENT

21 ESGE-ESGENA recommend embedding sustainability into the curricula of GI endoscopy.

STATEMENT

22 ESGE-ESGENA recommend conducting research into the environmental impact of GI endoscopy training. Waste reduction and awareness of the environmental costs during training are ethically linked to the notion of high quality GI endoscopy.

Table 5 Studies on single-use duodenoscopes: Cost–effectiveness analyses.

First author	Methodology	Assumptions	Results	Conflict of interest (COI), or funded by manufacturer of single-use endoscopes
Barakat [137]	Cost–utility analysis from facility viewpoint Outcomes: costs of different strategies (disposable cap, single or double high level disinfection [HLD], ethylene oxide, culture and hold, disposable duodenoscope) at different infection rates	▪ Residual contamination after reprocessing not given ▪ Transmission risk from infected endoscope: 30 % ▪ Infection risk after transmission: 50 % ▪ Treatment of infection (cholangitis): $375 000 ▪ Cost of single reprocessing: $131 ▪ Cost of disposable endoscope: $2991 ▪ Post ERCP lifespan: 7 years ▪ QALY value: $100K	At infection rate of < 1 %, disposable cap had the best cost–utility Disposable endoscopes preferred over single or double HLD at all infection rates Results not robust across sensitivity analyses Assumptions based on single studies or expert opinion. Results may change significantly with changes in these assumptions.	Not mentioned in journal pre-proof article. In other articles authors have disclosed research support from companies that manufacture single-use scopes.
Das [139]	Cost–effectiveness analysis from patient viewpoint Outcomes: Compare cost and QALYs of using disposable endoscope vs. different methods of reprocessing (single HLD, ethylene oxide, culture and hold) to reduce contamination risk of duodenoscope	▪ Residual contamination after reprocessing: 6 % ▪ Transmission risk from infected endoscope: 40 % ▪ Infection risk after transmission: 30 % ▪ Treatment of infection (cholangitis): $40 000 (additional probability ICU costs) ▪ Cost of single reprocessing: $200 ▪ Cost of disposable endoscope: $3000 ▪ Risk of long-term colonization: 40 % ▪ Willingness to pay: $100 000	HLD was least costly and disposable duodenoscope was the costliest. Incremental cost–effectiveness ratio for disposable duodenoscope was $62 185	Yes
Travis [138]	Microcosting analysis to determine cost of ERCP using reusable duodenoscopes. Data from 7 endoscopy units under one health care system in the United States	▪ Cost of reusable duodenoscope: $45 000 ▪ Cost of reprocessor: (AER): $35 400 ▪ Annual AER maintenance: $5000 ▪ Annual endoscope repair cost: $2500 ▪ Risk of infection from using reprocessed endoscope: 1 %–1.2 % ▪ Treatment of infection: $47 181	Total per procedure cost: ▪ 50 procedures/year, $2729 ▪ > 750 procedures/ year, $1292	Yes
Sahu [150]	Cost-minimization model to determine procedure cost with reusable endoscope and disposable sheath systems vs. single-use endoscopes. Only presented as conference abstract.	▪ Cost of reusable duodenoscope (average): $56 135 ▪ Annual cost of reprocessor (AER): $8166 ▪ Annual cost of maintenance: $140 337 ▪ Life of endoscope: 3 years ▪ Total cost/procedure: $687 ▪ Cost of disposable endoscope: $3500	Total per procedure cost: ▪ reusable endoscope, $687 ▪ single-use endoscope $426 Infection risk not considered	COI or funding not detailed in the abstract.

HLD, high level disinfection; QALY, quality-adjusted life-year; ERCP, endoscopic retrograde cholangiopancreatography; ICU, intensive care unit; AER, automated endoscope reprocessor.

▶ **Table 6** Studies on single-use duodenoscopes: Clinical studies.

First author	Study design	Sample size	Results	Infection risk compared with reusable endoscopes	COI or funded by manufacturer of single-use duodenoscopes
Napoléon [151]	Prospective case series Outcomes: completion rate, safety, operators' satisfaction	60	Completion rate: 95 % High operators' satisfaction Adverse events: 5 %	No	Yes
Lisotti [152]	Meta-analysis Outcomes: Technical success and adverse events	4 studies [151, 153, 155, 156] 381 patients	Technical success: 92.9 % Adverse events: 6.4 % Serious adverse events: 5.9 %	No	Yes
Muthusamy [153]	Case series Outcomes: feasibility, preliminary safety, performance	73	Procedure completion rate: 96.7 % Adverse events: 6.8 % Median overall satisfaction: 9/10	No	Yes
Ross [154]	Bench simulation study Outcomes: ability to complete tasks, subjective ratings, image quality, maneuverability	Preclinical study 3 reusable duodenoscopes vs. 1 single-use duodenoscope	Similar task completion times, tip control, and overall performance rating. Navigation was worse for the single-use duodenoscope.	No	Yes
Bang [155]	Randomized controlled trial Outcomes: number of attempts to achieve successful cannulation, crossover rate, maneuverability, adverse events	98	Single-use endoscopes required fewer attempts for successful cannulation. Ease of passage into stomach, image quality and stability, and air–water button functionality were significantly worse for single-use scopes Similar safety profile	No	Yes
Slivka [156]	Prospective case series Outcomes: completion of the procedure, crossover rate to another endoscope, device performance ratings, and serious adverse events.	200	Crossover rate: 9.5 % Adverse events: 6.5 % Similar results for experts and nonexperts High device performance ratings	No	Yes

COI, conflict of interest.

Several organizations and institutions already advocate integrating consideration of planetary health into medical and clinical education [4, 163]. Recently, the Association for Medical Education in Europe has developed a consensus statement to promote and outline the structural changes required [164]. While there are no data on the specific impact of training and educational activities of GI endoscopy, it is evident that it is associated with considerable environmental costs. The lack of research and awareness of this dimension of endoscopic practice argues for action by dedicated professional societies. Incorporating sustainability in endoscopy training is likely to influence the everyday practice of current and future GI endoscopists by optimizing resource utilization [19]. Raising awareness has been shown to be effective in other disciplines such as laparoscopic pediatric surgery, where giving individual surgeons a monthly report card that detailed the utilization and cost of disposable, high cost surgical supplies reduced the use of disposable trocars by 56 % [165]. Recommendations on environmentally friendly training alternatives, correct use and disposal of GI endoscopy devices [101], and overall attention to environmental issues can contribute to the ethical mindset of developing endoscopists. The incorporation of sustainability into the curricula of GI endoscopy requires the allocation of dedicated material, human, and time resources for trainers and trainees.

4.4.2 Reducing the carbon footprint during training and educational activities

STATEMENT

23 ESGE-ESGENA recommend that GI endoscopy training should be undertaken in structured, auditable programs and take into account local availability of endoscopy simulators and on-site/off-site teaching modules. Adoption of teaching strategies that shorten the learning curve and ensure safe and efficient procedures is essential to reduce unnecessary waste during training.

STATEMENT

24 ESGE-ESGENA suggest that virtual training and online educational modalities can reduce the environmental impact of GI endoscopy.

High quality training programs for fellows are an essential part of health care systems but incur significant material costs, due to potential prolongation of procedure time and hospitalization [166, 167], use of additional materials and instruments, or the need for dedicated spaces and equipment such as simulators [168]. While the structure and objectives of GI endoscopy training programs are highly variable across health care systems, strategies that reduce skill acquisition time and accelerate the learning curve are most likely to reduce the carbon footprint associated with training activities. Simulator training has been shown to be beneficial, especially in early skill acquisition, and may reduce procedure time and costs when trainees transition to procedures involving patients [169]. There is no consensus on the optimal type of simulator, and existing models offer different advantages and disadvantages from an ecological standpoint (e. g., reusability, need for explanted organs or live animals, electricity usage, etc.) [169].

Educational activities such as courses, congresses, and workshops contribute to the environmental footprint mainly due to transport-associated CO_2 emissions, redundant paper-based documentation, and avoidable items (e. g., leaflets, programs, advertisements, bags, cards, etc.) [170]. A recent life cycle assessment study concluded that the environmental impact of a virtual conference would be significantly less (4 tons CO_2 equivalent) than that of a traditional international face-to-face conference (192 tons CO_2 equivalent) [171]. In this sense, live endoscopy events are valuable educational activities that show a real-time approach to a clinical case by experts and minimize travel needs [172]. Adopting virtual/hybrid formats and electronic documentation where possible can contribute to the reduction of the carbon footprint.

Finally, responsibility in the choice of trainers for educational events could also reduce travel by encouraging the participation of local rather than foreign experts when local competence is available.

4.5 Green quality

4.5.1 Reducing the environmental impact of GI endoscopy by adherence to quality guidelines

STATEMENT

25 ESGE-ESGENA suggest that the implementation of and adherence to quality measures for GI endoscopy can reduce its environmental impact.

Our search did not find any study that directly assessed the impact of adhering to endoscopy quality guidelines on environmental outcomes. ESGE has been promoting quality in GI endoscopy since 2013 [173], and it is conceivable that adherence to key performance measures (KPMs) does not only improve patient outcomes [173], but also has a beneficial effect on the environment. Many of the ESGE KPMs focus on *doing less yet doing it better*. Thus, compliance with the following endoscopy service [41] and individual KPMs is expected to translate into a reduction in environmental impact:

- Appropriateness, as previously mentioned, increases the yield of endoscopy and reduces the number of unnecessary procedures [36, 37].
- Adequate fulfillment of KPMs for pre-endoscopy (i. e., rate of adequate bowel preparation > 90 % [174] and correct instructions for fasting > 95 % [175]) and for completeness of procedures (i. e., cecal intubation rate > 90 % [174], bile duct cannulation > 90 % [176], etc.), followed by proper management and identification of pathology, reduces the number of repeated procedures and allows adequate follow-up intervals. Standardized photo and video documentation facilitates referral and planning of therapeutic intervention, and potentially avoids repeated diagnostic procedures. The use of artificial intelligence (AI) during routine colonoscopy has the potential to improve the quality of endoscopy, particularly to assure a procedure's completeness [177]. Recent technological developments indeed enable automated assessment of bowel preparation and blind spots during endoscopy [178]. This is an additional effect that needs to be considered when calculating the cost–effectiveness of AI implementation in daily practice.
- Adequate endoscopist and staff training. Adherence to guidelines only translates into patient benefits if the endoscopist KPMs are met. These criteria include a high polyp detection rate and ability to remove polyps with regard to screening colonoscopies, or sufficient inspection time and appropriate biopsy sampling for specific conditions.
- Systematic electronic reporting. The first publication of the ESGE Quality Improvement Committee was on the prerequisites of electronic reporting systems and the need to develop these for measuring quality [179]. To facilitate quality assurance and, as a secondary effect, reduce endoscopy's carbon footprint, it is pivotal that quality assurance and automated guideline recommendations are incorporated into GI endoscopy reporting systems.

- Periodic inspection, calibration, and maintenance of facilities and equipment, especially decontamination and reprocessing circuits, are mandatory for energy-efficient service [41].

4.5.2 Sustainability as a new domain of high quality GI endoscopy

STATEMENT
26 ESGE-ESGENA recommend including sustainability as a quality domain for GI endoscopy.

Sustainability can be considered a part of quality health care [13]. Indeed, several health care organizations have already included sustainability as a critical domain of their conceptual quality framework [13]. Recently, the implementation of quality improvement in gastroenterology has been proposed to obtain a more environmentally sustainable delivery of endoscopy by the National Health Service in the United Kingdom [13, 46]. The process of developing environmental KPMs in endoscopy is beyond the scope of this document. Nonetheless, ESGE-ESGENA acknowledge that this is an unmet need that should be addressed in the coming years. Potential KPMs to be considered in the future are CO_2 emissions; waste; energy and water expended per endoscopy procedure [22]; mass of recycled and of total waste; renewable energy as a percentage of total energy used in the GI endoscopy unit, etc.

4.6 Green research and guidelines

4.6.1 Defining the roadmap for sustainable research in GI endoscopy

STATEMENT
27 ESGE-ESGENA should encourage and fund research into “green and sustainable” GI endoscopy.

STATEMENT
28 ESGE-ESGENA recommend conducting high quality research to quantify and minimize the environmental impact of GI endoscopy.

STATEMENT
29 ESGE-ESGENA recommend incorporating the principles of sustainability into every GI endoscopy research project. The study design should consider the environmental impact of the research.

▶ **Table 7** Actions for reducing the environmental impact of GI endoscopy research [164, 166–168].

Research phase	Action
Conception and rationale	1. Acknowledge sustainability as a core element of every research project. 2. Review the evidence systematically and check public study registries to avoid overlapping research. 3. Balance the pertinence and strategic relevance of the project within a multidisciplinary team. Involve patients and clinicians to define outcomes.
Design	1. Estimate an “efficient” sample size. 2. Design a statistical analysis plan before the study outset. 3. Involve methodologists. 4. Consider including environmental parameters as primary or secondary outcomes. 5. Take into account the environmental impact of the project. 6. Carefully consider the requirement for human and material resources. 7. Minimize travel requirement of the research team and the study population. Encourage public transport. 8. Restrict visits and complementary tests to what is strictly necessary for study purposes. 9. Consider replacing on-site visits with phone or virtual visits. 10. Consider the pertinence of answering more than one research question (e. g., factorial design or including an observational phase after a randomized controlled trial). 11. Reduce bureaucracy where possible.
Data collection, recruitment, and monitoring	1. Avoid unnecessary data collection. 2. Use paperless web-based case report forms and databases. 3. Use systematic, electronic, and centralized systems for auditing and monitoring the study. 4. Avoid unnecessary monitoring visits. 5. Consider conducting a carbon audit. 6. Transfer eco-friendly attitudes (Reduce-Reuse-Recycle) from home to the research project.
Reporting	1. Discuss the potential environmental impact of the results and raise awareness when possible. 2. Disseminate the results rapidly to avoid overlapping research. 3. Ensure that the information provided is reproducible and usable to other researchers. 4. Limit the number of on-site congresses where research is presented.

The task of minimizing the environmental impact of GI endoscopy starts with improving our understanding of the ecological impact of all its practices, procedures and devices. Research addressing these questions with regard to GI endoscopy is currently anecdotal [47]. Moreover, it is frequently overlooked that research activities themselves have a substantial carbon footprint. The Sustainable Clinical Trials Group has shown that RCTs generate hundreds of tonnes of CO_2 [180]. As an example, ClinicalTrials.gov has about 350 000 registered trials, which would generate CO_2 emissions of an estimated 27.5 million tonnes, almost equal to the total CO_2 emission of Switzerland (8.7 million population) in 2020 [181, 182]. Many of these emissions come from travel and are probably preventable [180]. A pertinent and thorough study design increases scientific validity and may also reduce the carbon footprint by increasing research efficiency [181].

ESGE-ESGENA should actively promote and support research that will allow us to understand the carbon footprint of GI endoscopy and help identify ways in which this impact can be minimized. To achieve this goal, ESGE-ESGENA favor not only including the concept of sustainability into every GI endoscopy research project (▶ **Table 7**) [181, 183–185], but also the performance of research specifically focused on environmental outcomes. While medico-economic dimensions may now be incorporated into research protocols, medico-ecological ones are not currently considered [186]. However, ecological impact should become a criterion [11, 186–188] in the choice of research strategy [85, 188–190]. A research agenda focused on the most urgent topics is proposed in ▶ **Table 8**.

4.6.2 Incorporating sustainability when grading the strength of recommendations

STATEMENT

30 ESGE-ESGENA recommend taking into account environmental impact when grading the strength of recommendations in GI endoscopy guidelines.

STATEMENT

31 ESGE-ESGENA suggest defining specific PICO (population/problem, intervention, comparison, outcome) questions to evaluate the environmental impact of guideline recommendations. In the absence of evidence, ESGE-ESGENA recommend highlighting the need for research to examine the environmental impact of the GI endoscopy guideline.

Many guidelines in all fields of medicine fail to consider resource utilization and the potential clinical and environmental harms that can derive from their recommendations [191]. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, which is currently used by most GI endoscopy guidelines, does not directly cite sustainability. However, it places resource use as a binding domain that contributes to the strength of recommendation (the more resource consumed, the less likely a strong recommendation is made) [192]. The recently established Cochrane Sustainable Health care group aims to reduce medical excess and underpin a needed shift towards an evidence-based synthesis process that weighs and prioritizes the environmental impact of medical actions [191]. Increased attention to all steps of the evidence chain is required to adequately balance the multifaceted effects of an

▶ **Table 8** Environmental research priorities in gastrointestinal (GI) endoscopy.

1	Strategies to reduce unnecessary GI endoscopic procedures and interventions and to lengthen follow-up intervals.
2	Define environmental outcomes related to the field of GI endoscopy.
3	Quantify the environmental impact of reusable GI endoscopes and accessories and identify strategies to reduce their carbon footprint.
4	Quantify the environmental impact of single-use GI endoscopes, and single-use accessories, and identify strategies to reduce their carbon footprint.
5	Quantify the environmental impact of GI endoscope reprocessing and identify strategies to minimize its carbon footprint.
6	Identify the carbon footprint of all types of GI endoscopic procedures at a per-procedure level.
7	Develop strategies for effectively reducing, reusing, and recycling all GI endoscopy-related equipment and waste.
8	Environmental impact of activities and practices related to training in GI endoscopy.
9	Define environmental key performance measures for green quality.
10	Telemedicine in GI endoscopy.

intervention. While acknowledging that there is minimal evidence on how to introduce the environmental impact of endoscopy into GI endoscopy guidelines, ESGE-ESGENA support that a change in mindset is required during the guideline development process in order to achieve sustainable health care.

4.7 Industry, health insurers, and health care providers

4.7.1 Encouraging companies to declare the environmental impact of their GI endoscopy products and to manufacture environmentally friendly devices

STATEMENT

32 ESGE-ESGENA recommend that GI endoscopy companies assess, disclose, and audit the environmental impact of their value chain.

STATEMENT

33 ESGE-ESGENA recommend that GI endoscopy companies manufacture environmentally friendly materials and devices.

STATEMENT

34 ESGE-ESGENA recommend against planned obsolescence of GI endoscopy materials and devices.

Currently, most GI endoscopy companies do not provide transparent, audited, and easy accessible information about the potential environmental impact of their products and practices. ESGE-ESGENA encourage GI endoscopy companies and manufacturers to adhere to the conceptual and legal frameworks developed by the EU and the United Nations [193, 194]. The European Green Deal, launched by the European Commission, includes a set of policies aimed at developing a more sustainable and environmentally friendly industrial model [193]. This strategy seeks to achieve a resource-efficient and competitive economy and advocates low-emission technologies, sustainable products, and services with no net GHG emission by 2050. Likewise, the United Nations Global Compact calls upon companies to align financial strategies and operations with universal principles on human rights, labor, anticorruption, and the environment; and to take actions to advance societal goals [195]. The United Nations code declares that companies should support a precautionary approach to environmental challenges, undertake initiatives to promote greater environmental responsibility, and encourage the development and diffusion of environmentally friendly technologies [194].

Ecological standards must apply to a product's total life cycle, from research and innovation to the extraction of raw materials, material formulation, manufacturing, packaging (often unnecessarily bulky and environmentally harmful [196]), distribution, usage, and waste disposal. ESGE-ESGENA encourage GI endoscopy companies to implement carbon offsetting programs, which enable companies to compensate for the carbon footprint secondary to their activities by supporting projects that reduce emissions elsewhere [197].

Planned obsolescence (i. e., designing and producing a product with an artificially limited lifespan) occurs in the health care industry and conflicts with sustainability, ethical principles, and the concept of a circular economy [198]. The optimal lifespan of high-tech devices, such as GI endoscopes, video processors, or electrosurgical units, depends on several factors such as national and local regulations, manufacturers' policies and amenability to technical maintenance. A minimum lifespan of 7–10 years is expected for endoscopes and devices of similar complexity [199]. Thus, replacing newer-generation devices before this timeframe seems only justified if new technologies impact clinically relevant outcomes or for research purposes. Finally, expiry dates of GI endoscopy accessories should be based on transparent and audited scientific evidence and not driven by commercial interests.

4.7.2 Advocating environmentally preferable purchasing

STATEMENT

35 ESGE-ESGENA recommend that governments, health insurers, and health care providers align with environmentally preferable purchasing strategies ("green purchasing"), including choosing materials and supplies with a low carbon footprint.

Governments, health insurers, and health care providers may also contribute to a more sustainable future by instituting environmentally preferable purchasing programs (i. e., purchasing products or services whose environmental impact has been assessed and found to be less damaging to the environment and human health when compared to competing alternatives). This has been termed "green public procurement" or "green purchasing" by the EU and promotes the policy that Europe's public authorities, including hospitals, use their purchasing power to choose environmentally friendly goods and services. This initiative demands the inclusion of transparent and verifiable environmental criteria for medical products in the public procurement process. Several European countries have already developed national guidelines to achieve this goal [193].

4.8 Policymakers, governments, and patients

4.8.1 Engaging policymakers and governments

STATEMENT

36 ESGE-ESGENA recommend that policymakers and governments take immediate action in the path towards environmentally sustainable GI endoscopy.

Policymakers, funding bodies, and governments play a crucial role in facilitating the transition towards green endoscopy. Areas of future regulation and policymaker engagement include:

- Mandating assessments of environmental impact as part of the EU medical device regulation approval and evaluation process.
- Encouragement of environmentally friendly GI endoscopy device alternatives by reimbursement incentives and penalties for less advantageous options.
- Promoting research grant initiatives for green endoscopy research projects by the EU, national or regional public funders, and policymakers.
- Inclusion of green endoscopy initiatives as part of local, regional, or national quality improvement programs in GI endoscopy.

- Policymaker-sponsored training programs for endoscopy managers, endoscopists, and patient organizations, to educate about green endoscopy alternatives and incentives.
- Educational programs for patients and citizens focused on promoting health, environmental sustainability, and rational use of health care resources.

4.8.2 Raising patient awareness and promoting patient empowerment

STATEMENT
37 ESGE-ESGENA recommend development of "Choosing Wisely" campaigns for GI endoscopy, discouraging overuse and overtreatment, and thus contributing to lower waste related to GI endoscopy, together with patients and patient organizations.

STATEMENT
38 ESGE-ESGENA suggest that patient empowerment programs and a healthy lifestyle can reduce the need for GI endoscopy procedures in the long term.

Data from the United Kingdom indicate that most patients (82 %) are concerned about climate change. Nevertheless, only a quarter think that the health care system significantly contributes to climate change and do not identify health care environmental sustainability as a priority [200]. Patients and individuals undergoing GI endoscopy for disease prevention purposes are to be encouraged to reduce waste and take environmentally conscious action in the following ways:

- Choose public over private transport. Favoring public transport can dramatically impact GHG emissions [201] and is feasible for most patients undergoing GI endoscopy, except for fragile or unfit patients who may require individual vehicles.
- Choose non-fossil fuel transport.
- Request "green endoscopy" information from GI endoscopy providers and choose those who provide such a service.
- Be aware of patient empowerment, defined by the World Health Organization as "a process through which people gain greater control over decisions and actions affecting their health" [202]. Patient empowerment is promoted by the EU and positively impacts health [203, 204]. Patients should be conscious about the usage of GI endoscopy services related to medical needs, pay attention to, and engage in "Choosing Wisely" campaigns against overusage of endoscopy.
- Primary prevention can also reduce the need for GI endoscopy in the long run. Compelling evidence indicates that a healthy lifestyle reduces the risk of several GI diseases that often demand endoscopy, such as gastroesophageal reflux disease, functional dyspepsia, colorectal cancer, and metabolic-associated fatty liver disease.
- Be conscious of absolute benefits and harms of GI endoscopy services related to single-use or reusable equipment.

5 Conclusions

STATEMENT
39 ESGE-ESGENA recommend that GI endoscopy should become a net-zero GHG emissions practice by 2050.

Global warming and the destruction of ecosystems are among the greatest and most complex threats to humanity. GI endoscopy is a resource-demanding activity and a probable major contributor to the environmental impact of health care. The scientific community has unanimously called for emergency action to limit global temperature increases, restore biodiversity, and protect health. Through this Position Statement, ESGE-ESGENA encourage health care providers, patients, companies, policymakers, and governments to act proactively against the climate challenge. The current climate crisis demands not only a green mindset for nurses and physicians but that all stakeholders involved in GI endoscopy work together for a more sustainable future.

Herein, we provide short- and long-term actionable strategies for more sustainable GI endoscopy (▶**Fig. 2** and ▶**Fig. 3**). It is crucial to take into account GI endoscopy's environmental and social impact while keeping patients' clinical outcomes as the priority. The most immediate actions are to reduce the rate of unnecessary procedures and to embed circular economy principles into GI endoscopy practice. Single-use devices can reduce infection risk and have become increasingly popular, but studies including life cycle assessment are urgently needed to better assess their environmental viability. In line with the EU climate goals [205], GI endoscopy net-zero GHG emissions by 2050, or ideally even before, should become a firm and common goal.

Disclaimer

The legal disclaimer for ESGE Guidelines as described in the 2020 Publications Policy update [206] applies to this Position Statement.

Competing interests

M. Arvanitakis is providing consultancy to Ambu (September 2021 to September 2022). E. Bak is Chair of the Polish Society of Endoscopic Nurses and Assistants (from 2019, ongoing). M. Dinis-Ribeiro has provided consultancy to Medtronic (from 2021 and Roche (from 2022); his department has received a research grant (loan) from Fujifilm (2021–2022); he is Co-Editor-in-Chief of *Endoscopy* journal. A. Eickhoff has provided consultancy to Ambu Medical (2012–2020). L. Donnelly is an elected member of the British Society of Gastroenterology – Nurses Association (2022, ongoing). C. Hassan has provided consultancy to and/or received research grants from Alfasigma, Fujifilm, Medtronic, Norgine, Olympus, and Pentax. B.H. Hayee is receiving grant support for sustainability research from Boston Scientific (from April 2022 for 24 months). M.F. Kaminski has provided consultancy to Olympus and Erbe (from 2021), and lectured for Boston Scientific (from 2016) and Recordati (from 2020). H. Messmann has received consultation fees from Ambu, Boston Scientific, and Olympus (in the past 3 years); his department has received financial support from Olympus and Satisfai. M. Pellisé has provided consultancy to Norgine Iberia (2015–2019), CI Supply (2019), and Fujifilm Europe (from 2021, ongoing); her department has received research support from Fujifilm Spain (2019), Fujifilm Europe (from 2020, ongoing), Casen Recordati (2020), ZiuZ (2021), and 3D-Matrix (2022); she is Chair of the ESGE Diversity and Equity Working Group (2021–2022) and a Councillor for SEED (Sociedad Española de Endoscopia Digestiva) (2016–2022). H. Pohl is Co-Editor-in-Chief of *Endoscopy* journal. E. Rodríguez de Santiago receives support for academic and educational activities with Olympus (from 2021, ongoing); his department receives support for academic and educational activities with Olympus, Boston Scientific, Casen Recordati, and Norgine (from 2016, ongoing). P.D. Siersema receives research support from Pentax, Japan (from 2019), The E-Nose Company, Netherlands (from 2018), Lucid Diagnostics, US (from 2021), MicroTech, China (from 2019), and Magentiq Eye, Israel (from 2021); he receives research support from and advises Motus GI, US (from 2018), and support from Endo Tools Therapeutics, Belgium (2022); he is Editor-in-Chief of *Endoscopy* journal. A. Veitch has received speaker's fees from Olympus (March 2022). G.J. Webster has received honoraria for teaching from Boston Scientific (2010–2022). D. Agrawal, R. Baddeley, U. Beilenhoff, P. Bhandari, R. Bisschops, M. Bretthauer, P. Burga, I.M. Gralnek, K. Karlović, V. Lorenzo-Zuniga, M. Pioche, K. Siau, W. Stableforth, T.C. Tham, K. Triantafyllou, A. Tringali, A. Vienne, and A. Voiosu have no competing interests.

References

[1] National Aeronautics and Space Administration. Global Climate Change. Vital signs of the planet. https://climate.nasa.gov/

[2] Masson-Delmotte V, Zhai P, Pirani A. IPCC. et al. Climate change 2021: The physical science basis. Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change 2021. https://www.ipcc.ch/sr15/chapter/spm/

[3] Centers for Disease Control and Prevention (CDC). Preparing for the regional health impacts of climate change in the United States 2020. https://www.cdc.gov/climateandhealth/docs/Health_Impacts_Climate_Change-508_final.pdf

[4] van Daalen K, Füssel HM, Kazmierczak A et al. Responding to the health risks of climate change in Europe. March 2021. Lancet Countdown on Health and Climate Change and the European Environment Agency. https://www.dropbox.com/s/2dib9sjaz9xxszb/Responding%20to%20the%20health%20risks%20of%20climate%20change%20in%20Europe.pdf?dl=0

[5] Lenzen M, Malik A, Li M et al. The environmental footprint of health care: a global assessment. Lancet Planet Health 2020; 4: e271–e279. doi:10.1016/S2542-5196(20)30121-2

[6] Siau K, Hayee B, Gayam S. Endoscopy's current carbon footprint. Techn Innov Gastrointest Endosc 2021; 23: 344–352. doi:10.1016/j.tige.2021.06.005

[7] Hassan C, Ponchon T, Bisschops R et al. European Society of Gastrointestinal Endoscopy (ESGE) Publications Policy – Update 2020. Endoscopy 2020; 52: 123–126. doi:10.1055/a-1067-4657

[8] Bahraini A. Waste4Change Supports 3R (Reduce-Reuse-Recycle) Green Concept! Waste4Change 2019. Accessed: 24 Jan 2022 at: https://waste4change.com/blog/waste4change-supports-3r-reduce-reuse-recycle-green-concept

[9] Carbon Trust. Carbon footprinting guide. Accessed: 26 Jan 2022 at: https://www.carbontrust.com/resources/carbon-footprinting-guide

[10] European Parliament. News. 2 Dec 2015. Circular economy: definition, importance and benefits. Accessed: 24 Jan 2022 at: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

[11] Intergovernmental Panel on Climate Change (IPCC). Global warming of 1.5 °C. Glossary. Accessed: 24 Jan 2022 at: https://www.ipcc.ch/sr15/chapter/glossary

[12] Maurice JB, Siau K, Sebastian S et al. Green endoscopy: a call for sustainability in the midst of COVID-19. Lancet Gastroenterol Hepatol 2020; 5: 636–638. doi:10.1016/S2468-1253(20)30157-6

[13] Centre for Sustainable Healthcare (CSH) Networks. Green Endoscopy. Accessed: 25 Jan 2022 at: https://networks.sustainablehealthcare.org.uk/network/green-endoscopy

[14] Greenhouse Gas Protocol. About us. Accessed: 12 Mar 2022 at: https://ghgprotocol.org/about-us

[15] Arup and Health Care Without Harm. Healthcare's climate footprint. Accessed: 26 Jan 2022 at: https://www.arup.com/en/perspectives/publications/research/section/healthcares-climate-footprint

[16] Mortimer F, Isherwood J, Wilkinson A et al. Sustainability in quality improvement: redefining value. Future Healthc J 2018; 5: 88–93. doi:10.7861/futurehosp.5-2-88

[17] Rasheed FN, Baddley J, Prabhakaran P et al. Decarbonising healthcare in low and middle income countries: potential pathways to net zero emissions. BMJ 2021; 375: n1284. doi:10.1136/bmj.n1284

[18] Eckelman MJ, Huang K, Lagasse R et al. Health care pollution and public health damage in the United States: An update. Health Aff (Millwood) 2020; 39: 2071–2079

[19] Vaccari M, Tudor T, Perteghella A. Costs associated with the management of waste from healthcare facilities: An analysis at national and site level. Waste Manag Res 2018; 36: 39–47. doi:10.1177/0734242X17739968

[20] European Commission. Environment. Integrated Product Policy. European Platform on Life Cycle Assessment. Accessed: 26 Jan 2022 at: https://ec.europa.eu/environment/ipp/lca.htm

[21] Gayam S. Environmental impact of endoscopy: "Scope" of the problem. Am J Gastroenterol 2020; 115: 1931–1932. doi:10.14309/ajg.0000000000001005

[22] Namburar S, von Renteln D, Damianos J et al. Estimating the environmental impact of disposable endoscopic equipment and endoscopes. Gut 2021: doi:10.1136/gutjnl-2021-324729

[23] Gordon IO, Sherman JD, Leapman M et al. Life cycle greenhouse gas emissions of gastrointestinal biopsies in a surgical pathology laboratory. Am J Clin Pathol 2021; 156: 540–549. doi:10.1093/ajcp/aqab021

[24] Hernandez LV, Le NNT, Patnode C et al. Comparing the impact of reusable and single-use duodenoscopes using life cycle assessment. Gastrointest Endosc 2021; 93: AB29. doi:10.1016/j.gie.2021.03.123

[25] Olympus Medical Systems. Accessed: 22 Jan 2022 at: https://www.olympus-europa.com/medical/en/Home/

[26] Fujifilm Endoscopy. Accessed: 22 Jan 2022 at: https://www.fujifilm-endoscopy.com/products

[27] Williams D. Essential biomaterials science. Cambridge: Cambridge University Press; 2014

[28] Goldis A, Goldis R, Chirila TV. Biomaterials in gastroenterology: A critical overview. Medicina (Kaunas) 2019; 55: E734. doi:10.3390/medicina55110734

[29] Ministry of Environment of Denmark Environmental Protection Agency. Fact sheet: PVC and phthalates. Accessed: 02 Mar 2022 at: https://eng.mst.dk/chemicals/chemicals-in-products/legal-framework-for-managing-chemicals/fact-sheets/fact-sheet-pvc-and-phthalates/

[30] Regulation (EU) 2017/745 of the European Parliament and of the Council on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC. Regulations 2017. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0745

[31] Early DS, Ben-Menachem T et al. ASGE Standards of Practice Committee. Appropriate use of GI endoscopy. Gastrointest Endosc 2012; 75: 1127–1131. doi:10.1016/j.gie.2012.01.011

[32] Rodríguez-de-Santiago E, Frazzoni L, Fuccio L et al. Digestive findings that do not require endoscopic surveillance – Reducing the burden of care: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement. Endoscopy 2020; 52: 491–497. doi:10.1055/a-1137-4721

[33] Elli L, Tontini GE, Filippi E et al. Efficacy of endoscopic triage during the Covid-19 outbreak and infective risk. Eur J Gastroenterol Hepatol 2020; 32: 1301–1304. doi:10.1097/MEG.0000000000001856

[34] Edwards R, Foulser P, Gould S et al. PTH-23 Consultant triage of endoscopy waiting lists during the Covid-19 pandemic saves money and reduces workload. Gut 2021; 70: A182–A182. doi:10.1136/gutjnl-2021-BSG.338

[35] Marín-Gabriel JC, de Santiago ER. en representación de la Asociación Española de Gastroenterología y la Sociedad Española de Endoscopia Digestiva. AEG-SEED position paper for the resumption of endoscopic activity after the peak phase of the COVID-19 pandemic. Gastroenterol Hepatol 2020; 43: 389–407. doi:10.1016/j.gastrohep.2020.05.004

[36] Frazzoni L, La Marca M, Radaelli F et al. Systematic review with meta-analysis: the appropriateness of colonoscopy increases the probability of relevant findings and cancer while reducing unnecessary exams. Aliment Pharmacol Ther 2021; 53: 22–32. doi:10.1111/apt.16144

[37] Zullo A, Manta R, De Francesco V et al. Diagnostic yield of upper endoscopy according to appropriateness: A systematic review. Dig Liver Dis 2019; 51: 335–339. doi:10.1016/j.dld.2018.11.029

[38] Tavakkoli A, Appelman HD, Beer DG et al. Use of appropriate surveillance for patients with nondysplastic Barrett's esophagus. Clin Gastroenterol Hepatol 2018; 16: 862–869.e3. doi:10.1016/j.cgh.2018.01.052

[39] Djinbachian R, Dubé A-J, Durand M et al. Adherence to post-polypectomy surveillance guidelines: a systematic review and meta-analysis. Endoscopy 2019; 51: 673–683. doi:10.1055/a-0865-2082

[40] Shandro B, Chang V, Mathur J et al. Real-life cost savings and capacity improvements on implementation of the new BSG post-polypectomy surveillance guideline. Clin Med (Lond) 2020; 20: 116–117. doi:10.7861/clinmed.2019-0401

[41] Valori R, Cortas G, de Lange T et al. Performance measures for endoscopy services: a European Society of Gastrointestinal Endoscopy (ESGE) Quality Improvement Initiative. Endoscopy 2018; 50: 1186–1204. doi:10.1055/a-0755-7515

[42] Pasha SF, Acosta R. ASGE Standards of Practice Committee. et al. Routine laboratory testing before endoscopic procedures. Gastrointest Endosc 2014; 80: 28–33. doi:10.1016/j.gie.2014.01.019

[43] Richie C. Environmental sustainability and the carbon emissions of pharmaceuticals. J Med Ethics 2021: doi:10.1136/medethics-2020-106842

[44] Weisz U, Pichler P, Jaccard I et al. Ergebnisse der Studie HealthFootprint CO_2-Fussabdruck des österreichischen Gesundheitssektors [in German]. Accessed: 02 Feb 2022 at: https://www.klimafonds.gv.at/wp-content/uploads/sites/16/HealthFootprint_Einleitung-und-Kernausssagen-lektoriert.pdf

[45] Sulbaek Andersen MP, Nielsen OJ, Wallington TJ et al. Medical intelligence article: assessing the impact on global climate from general anesthetic gases. Anesth Analg 2012; 114: 1081–1085. doi:10.1213/ANE.0b013e31824d6150

[46] NHS England. Delivering a "net zero" National Health Service. Accessed: 12 Dec 2022 at: https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf

[47] Baddeley R, de Santiago ER, Maurice J et al. Sustainability in gastrointestinal endoscopy. Lancet Gastroenterol Hepatol 2021: doi:10.1016/S2468-1253(21)00389-7

[48] Pin-Vieito N, Puga M et al. Fernández-de-Castro D. Faecal immunochemical test outside colorectal cancer screening? World J Gastroenterol 2021; 27: 6415–6429. doi:10.3748/wjg.v27.i38.6415

[49] Jukic A, Bakiri L, Wagner EF et al. Calprotectin: from biomarker to biological function. Gut 2021; 70: 1978–1988. doi:10.1136/gutjnl-2021-324855

[50] Rodríguez de Santiago E, Téllez L, Garrido-Lestache Rodríguez-Monte E et al. Fontan protein-losing enteropathy is associated with advanced liver disease and a proinflammatory intestinal and systemic state. Liver Int 2020; 40: 638–645. doi:10.1111/liv.14375

[51] Gisbert JP, Alcedo J, Amador J et al. V Spanish Consensus Conference on Helicobacter pylori infection treatment. Gastroenterol Hepatol 2021: doi:10.1016/j.gastrohep.2021.07.011

[52] Januszewicz W, Tan WK, Lehovsky K et al. Safety and acceptability of esophageal cytosponge cell collection device in a pooled analysis of data from individual patients. Clin Gastroenterol Hepatol 2019; 17: 647–656.e1. doi:10.1016/j.cgh.2018.07.043

[53] de Franchis R. Baveno VI Faculty. Expanding consensus in portal hypertension: Report of the Baveno VI Consensus Workshop: Stratifying risk and individualizing care for portal hypertension. J Hepatol 2015; 63: 743–752

[54] Pennazio M, Spada C, Eliakim R et al. Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel disorders: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. Endoscopy 2015; 47: 352–376. doi:10.1055/s-0034-1391855

[55] Cave D, Saltzman JR, Travis AC. Wireless video capsule endoscopy. UpToDate. Accessed: 10 Nov 2021 at: https://www.uptodate.com/contents/wireless-video-capsule-endoscopy?search=Cave%20D,%20Saltzman%20JR,%20Travis%20AC.%20Wireless%20video%20capsule%20endoscopy.&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1

[56] Grant RK, Brindle WM, Robertson AR et al. Unsedated transnasal endoscopy: a safe, well-tolerated and accurate alternative to standard diagnostic peroral endoscopy. Dig Dis Sci 2022: 1–11. doi:10.1007/s10620-022-07432-9

[57] Dobrusin A, Hawa F, Gladshteyn M et al. Gastroenterologists and patients report high satisfaction rates with telehealth services during the novel coronavirus 2019 pandemic. Clin Gastroenterol Hepatol 2020; 18: 2393–2397.e2. doi:10.1016/j.cgh.2020.07.014

[58] Keihanian T, Sharma P, Goyal J et al. Telehealth utilization in gastroenterology clinics amid the COVID-19 pandemic: impact on clinical practice and gastroenterology training. Gastroenterology 2020; 159: 1598–1601. doi:10.1053/j.gastro.2020.06.040

[59] Purohit A, Smith J, Hibble A. Does telemedicine reduce the carbon footprint of healthcare? A systematic review Future Healthc J 2021; 8: e85–e91. doi:10.7861/fhj.2020-0080

[60] Pouw RE, Barret M, Biermann K et al. Endoscopic tissue sampling – Part 1: Upper gastrointestinal and hepatopancreatobiliary tracts. European Society of Gastrointestinal Endoscopy (ESGE) Guideline. Endoscopy 2021; 53: 1174–1188. doi:10.1055/a-1611-5091

[61] Pouw RE, Bisschops R, Gecse KB et al. Endoscopic tissue sampling – Part 2: Lower gastrointestinal tract. European Society of Gastrointestinal Endoscopy (ESGE) Guideline. Endoscopy 2021: 1261–1273. doi:10.1055/a-1671-6336

[62] Thosani N, Abu Dayyeh BK. ASGE Technology Committee. et al. ASGE Technology Committee systematic review and meta-analysis assessing the ASGE Preservation and Incorporation of Valuable Endoscopic Innovations thresholds for adopting real-time imaging-assisted endoscopic targeted biopsy during endoscopic surveillance of Barrett's esophagus. Gastrointest Endosc 2016; 83: 684–698.e7. doi:10.1016/j.gie.2016.01.007

[63] Bisschops R, East JE, Hassan C et al. Advanced imaging for detection and differentiation of colorectal neoplasia: European Society of Gastrointestinal Endoscopy (ESGE) Guideline – Update 2019. Endoscopy 2019; 51: 1155–1179. doi:10.1055/a-1031-7657

[64] Dekker E, Houwen BBSL, Puig I et al. Curriculum for optical diagnosis training in Europe: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement. Endoscopy 2020; 52: 899–923. doi:10.1055/a-1231-5123

[65] Rutter MD, East J, Rees CJ et al. British Society of Gastroenterology/Association of Coloproctology of Great Britain and Ireland/Public Health England post-polypectomy and post-colorectal cancer resection surveillance guidelines. Gut 2020; 69: 201–223. doi:10.1136/gutjnl-2019-319858

[66] Abu Dayyeh BK, Thosani N. ASGE Technology Committee. et al. ASGE Technology Committee systematic review and meta-analysis assessing the ASGE PIVI thresholds for adopting real-time endoscopic assessment of the histology of diminutive colorectal polyps. Gastrointest Endosc 2015; 81: 502.e1–502.e16. doi:10.1016/j.gie.2014.12.022

[67] Rex DK, Kahi C, O'Brien M et al. The American Society for Gastrointestinal Endoscopy PIVI (Preservation and Incorporation of Valuable Endoscopic Innovations) on real-time endoscopic assessment of the histology of diminutive colorectal polyps. Gastrointest Endosc 2011; 73: 419–422. doi:10.1016/j.gie.2011.01.023

[68] Gulati S, Emmanuel A, Ong M et al. Near-focus narrow-band imaging classification of villous atrophy in suspected celiac disease: development and international validation. Gastrointest Endosc 2021: 1071–1081. doi:10.1016/j.gie.2021.06.031

[69] Turan AS, Didden P, Peters Y et al. Factors involved in endoscopists' choice for prophylactic clipping after colorectal endoscopic mucosal resection: a discrete choice experiment. Scand J Gastroenterol 2020; 55: 737–744. doi:10.1080/00365521.2020.1770851

[70] Day LW, Muthusamy VR, Collins J et al. Multisociety guideline on reprocessing flexible GI endoscopes and accessories. Gastrointest Endosc 2021; 93: 11–33.e6. doi:10.1016/j.gie.2020.09.048

[71] Beilenhoff U, Biering H, Blum R et al. Reprocessing of flexible endoscopes and endoscopic accessories used in gastrointestinal endoscopy: Position Statement of the European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology Nurses and Associates (ESGENA) – Update 2018. Endoscopy 2018; 50: 1205–1234. doi:10.1055/a-0759-1629

[72] Agrawal D, Rockey DC. Sterile water in endoscopy: habit, opinion, or evidence. Gastrointest Endosc 2013; 78: 150–152. doi:10.1016/j.gie.2013.02.031

[73] Huang C, Choong M. Comparison of wounds' infection rate between tap water and normal saline cleansing: A meta-analysis of randomised control trials. Int Wound J 2018; 16: 300–301. doi:10.1111/iwj.12980

[74] Puterbaugh M, Barde C, Van Enk R. Endoscopy water source: tap or sterile water? Gastroenterol Nurs 1997; 20: 203–206. doi:10.1097/00001610-199711000-00003

[75] Wilcox CM, Waites K, Brookings ES. Use of sterile compared with tap water in gastrointestinal endoscopic procedures. Am J Infect Control 1996; 24: 407–410. doi:10.1016/s0196-6553(96)90031-0

[76] Kawamura T, Sakai H, Ogawa T et al. Feasibility of underwater endoscopic mucosal resection for colorectal lesions: a single center study in Japan. Gastroenterology Res 2018; 11: 274–279. doi:10.14740/gr1021w

[77] Fischer LS, Lumsden A, Leung FW. Water exchange method for colonoscopy: learning curve of an experienced colonoscopist in a U.S. community practice setting. J Interv Gastroenterol 2012; 2: 128–132. doi:10.4161/jig.23734

[78] Cadoni S, Ishaq S, Hassan C et al. Water-assisted colonoscopy: an international modified Delphi review on definitions and practice recommendations. Gastrointest Endosc 2021; 93: 1411–1420.e18. doi:10.1016/j.gie.2020.10.011

[79] Tennison I, Roschnik S, Ashby B et al. Health care's response to climate change: a carbon footprint assessment of the NHS in England. Lancet Planet Health 2021; 5: e84–e92. doi:10.1016/S2542-5196(20)30271-0

[80] Baldaque-Silva F, Marques M, Andrade AP et al. Endoscopic submucosal dissection of gastrointestinal lesions on an outpatient basis. United European Gastroenterol J 2019; 7: 326–334. doi:10.1177/2050640618823874

[81] Zhang LY, Bejjani M, Ghandour B et al. Rethinking the need for overnight admission after peroral endoscopic myotomy (POEM): a pandemic-driven approach to the future. Endosc Int Open 2021; 9: E1381–E1385. doi:10.1055/a-1490-9385

[82] Coté GA, Lynch S, Easler JJ et al. Development and validation of a prediction model for admission after endoscopic retrograde cholangiopancreatography. Clin Gastroenterol Hepatol 2015; 13: 2323–2332.e1-9. doi:10.1016/j.cgh.2015.06.023

[83] Rizan C, Steinbach I, Nicholson R et al. The carbon footprint of surgical operations: a systematic review. Ann Surg 2020; 272: 986–995. doi:10.1097/SLA.0000000000003951

[84] Grinberg D, Buzzi R, Pozzi M et al. Eco-audit of conventional heart surgery procedures. Eur J Cardiothorac Surg 2021; 60: 1325–1331. doi:10.1093/ejcts/ezab320

[85] Thiel CL, Woods NC, Bilec MM. Strategies to reduce greenhouse gas emissions from laparoscopic surgery. Am J Public Health 2018; 108: S158–S164. doi:10.2105/AJPH.2018.304397

[86] Mulder CJJ, Jacobs MAJM, Leicester RJ et al. Guidelines for designing a digestive disease endoscopy unit: report of the World Endoscopy Organization. Dig Endosc 2013; 25: 365–375. doi:10.1111/den.12126

[87] Part B – Health Facility Briefing & Design. International Health Facility Guidelines Version 4 May 2014. Accessed: 01 Nov 2021 at: https://healthfacilityguidelines.com/ViewPDF/ViewIndexPDF/iHFG_part_b_complete

[88] Özkan S, Gökdag B. Reflections of sustainable design principles into hospital interiors; investigation of Boulder Community Foothills Hospital and VKV American Hospital in the green hospital context. IAI Academic Conference Proceedings, September 2019; Rome, Italy. Accessed: 4 Dec 2021 at: https://www.academia.edu/es/43106340/reflections_of_sustainable_design_principles_into_hospital_interiors_investigation_of_Boulder_Community_Foothills_Hospital_and_VKV_American_Hospital_in_the_green_hospital_context

[89] Büyüksa S, Aydin D, Yaldiz E. Sustainable hospital design for sustainable development. Accessed: 04 Dec 2021 at: https://www.academia.edu/44406203/Sustainable_Hospital_Design_for_Sustainable_Development

[90] Tomson C. Reducing the carbon footprint of hospital-based care. Future Hosp J 2015; 2: 57–62. doi:10.7861/futurehosp.2-1-57

[91] Borges de Oliveira K, dos Santos EF, Neto AF et al. Guidelines for efficient and sustainable energy management in hospital buildings. J Clean Prod 2021; 329: 129644. doi:10.1016/j.jclepro.2021.129644

[92] Gutierrez-Aliaga L, Williams E. Co-alignment of comfort and energy saving objectives for U.S. office buildings and restaurants. . Sustain Cities Soc 2016; 27: 32–41. doi:10.1016/j.scs.2016.08.010

[93] Calderwood AH, Chapman FJ. ASGE Ensuring Safety in the Gastrointestinal Endoscopy Unit Task Force. et al. Guidelines for safety in the gastrointestinal endoscopy unit. Gastrointest Endosc 2014; 79: 363–372. doi:10.1016/j.gie.2013.12.015

[94] Thiel CL, Eckelman M, Guido R et al. Environmental impacts of surgical procedures: life cycle assessment of hysterectomy in the United States. Environ Sci Technol 2015; 49: 1779–1786. doi:10.1021/es504719g

[95] Day LW, Belson D. Studying and incorporating efficiency into gastrointestinal endoscopy centers. Gastroenterol Res Pract 2015; 2015: 764153. doi:10.1155/2015/764153

[96] Martínez J, Aparicio JR, Peña A et al. The current situation of digestive endoscopy units in the Valencian community. Rev Esp Enferm Dig 2019; 111: 556–562. doi:10.17235/reed.2019.5676/2018

[97] Wu J, Zhao S-B, Wang S-L et al. Comparison of efficacy of colonoscopy between the morning and afternoon: A systematic review and meta-analysis. Dig Liver Dis 2018; 50: 661–667. doi:10.1016/j.dld.2018.03.035

[98] Dri M, Canfora P, Antonopoulos I. European Commission, Joint Research Centre. et al. Best environmental management practice for the waste management sector: learning from frontrunners. Publications Office 2018. Accessed: 13 Jan 2022 at: https://data.europa.eu/doi/10.2760/50247

[99] European Circular Economy Stakeholder Platform. Sustainable healthcare waste management in the EU Circular Economy model. Accessed: 3 Mar 2022 at: https://circulareconomy.europa.eu/platform/en/toolkits-guidelines/sustainable-healthcare-waste-management-eu-circular-economy-model

[100] Babanyara YY, Ibrahim BD, Garba T et al. Poor medical waste management (MWM) practices and its risks to human health and the environment: a literature review. Int J Health Med Eng 2013; 7: 780–787

[101] Agrawal D, Shoup V, Montgomery A et al. Disposal of endoscopic accessories after use: do we know and do we care? Gastroenterol Nurs 2017; 40: 13–18. doi:10.1097/SGA.0000000000000280

[102] Turley M, Porter C, Garrido T et al. Use of electronic health records can improve the health care industry's environmental footprint. Health Aff (Millwood) 2011; 30: 938–946. doi:10.1377/hlthaff.2010.1215

[103] Rutgers University. The supply chain/Green purchasing overview. Accessed: 21 Dec 2021 at: http://greenpurchasing.rutgers.edu/supply_chain.html

[104] Energy Star. Top 10 computer power management myths…and realities. Accessed: 4 Dec 2021 at: https://www.energystar.gov/products/low_carbon_it_campaign/put_your_computers_sleep/myths_realities

[105] Roisin B, Bodart M, Deneyer A et al. Lighting energy savings in offices using different control systems and their real consumption. Energ Buildings 2008; 40: 514–523. doi:10.1016/j.enbuild.2007.04.006

[106] Ponchon T, Pioche M. Reprocessing single-use devices: A new season in a long-running show? A European perspective Endoscopy 2017; 49: 1195–1197. doi:10.1055/s-0043-121988

[107] Wang F, Zhang D, Zeng J et al. Comparison of endoscopic radial incision and Savary–Gilliard's bougie dilation in efficacy on refractory esophagogastric anastomosis strictures. Ann Palliat Med 2021; 10: 10963–10970. doi:10.21037/apm-21-2648

[108] Piotet E, Escher A, Monnier P. Esophageal and pharyngeal strictures: report on 1,862 endoscopic dilatations using the Savary–Gilliard technique. Eur Arch Otorhinolaryngol 2008; 265: 357–364. doi:10.1007/s00405-007-0456-0

[109] Robles-Medranda C, Oleas R, Alvarado-Escobar H et al. Treating simple benign esophageal strictures with Savary–Gilliard dilators: is the rule of three still necessary? Arq Gastroenterol 2019; 56: 95–98. doi:10.1590/S0004-2803.201900000-21

[110] Jung M, Beilenhoff U, Pietsch M et al. Standardized reprocessing of reusable colonoscopy biopsy forceps is effective: results of a German multicenter study. Endoscopy 2003; 35: 197–202. doi:10.1055/s-2003-37270

[111] Rizzo J, Bernstein D, Gress F. A performance, safety and cost comparison of reusable and disposable endoscopic biopsy forceps: a prospective, randomized trial. Gastrointest Endosc 2000; 51: 257–261. doi:10.1016/s0016-5107(00)70351-8

[112] Yoon JH, Yoon BC, Lee HL et al. Comparison of sterilization of reusable endoscopic biopsy forceps by autoclaving and ethylene oxide gas. Dig Dis Sci 2012; 57: 405–412. doi:10.1007/s10620-011-1884-7

[113] Visrodia K, Haseeb A, Hanada Y et al. Reprocessing of single-use endoscopic variceal band ligation devices: a pilot study. Endoscopy 2017; 49: 1202–1208. doi:10.1055/s-0043-115004

[114] Kozarek RA, Raltz SL, Ball TJ et al. Reuse of disposable sphincterotomes for diagnostic and therapeutic ERCP: a one-year prospective study. Gastrointest Endosc 1999; 49: 39–42. doi:10.1016/s0016-5107(99)70443-8

[115] Wilcox CM, Geels W, Baron TH. How many times can you reuse a "single-use" sphincterotome? A prospective evaluation Gastrointest Endosc 1998; 48: 58–60. doi:10.1016/s0016-5107(98)70130-0

[116] Lee RM, Vida F, Kozarek RA et al. In vitro and in vivo evaluation of a reusable double-channel sphincterotome. Gastrointest Endosc 1999; 49: 477–482. doi:10.1016/s0016-5107(99)70046-5

[117] Kozarek RA, Raltz SL, Brandabur JJ et al. In vitro study and in vivo application of a reusable double-channel sphincterotome. Endoscopy 2001; 33: 401–404. doi:10.1055/s-2001-14262

[118] Prat F, Spieler J-F, Paci S et al. Reliability, cost-effectiveness, and safety of reuse of ancillary devices for ERCP. Gastrointest Endosc 2004; 60: 246–252. doi:10.1016/s0016-5107(04)01685-2

[119] Cohen J, Haber GB, Kortan P et al. A prospective study of the repeated use of sterilized papillotomes and retrieval baskets for ERCP: quality and cost analysis. Gastrointest Endosc 1997; 45: 122–127. doi:10.1016/s0016-5107(97)70233-5

[120] Ende A, Zopf Y, Heide R et al. Hemodynamic efficacy of sequential hemoclip application using the Olympus HX-110/610 reloadable clipping device in spurting bleedings. Med Sci Monit 2011; 17: MT1–MT6. doi:10.12659/msm.881313

[121] Cheung DY, Jang BI, Kim SW et al. Multidisciplinary and multisociety practice guideline on reprocessing flexible gastrointestinal endoscopes and endoscopic accessories. Clin Endosc 2020; 53: 276–285. doi:10.5946/ce.2020.106

[122] Limani F, Garley D, Cocker D et al. Lessons learnt from the rapid implementation of reusable personal protective equipment for COVID-19 in Malawi. BMJ Glob Health 2021; 6: e006498. doi:10.1136/bmjgh-2021-006498

[123] Reynier T, Berahou M, Albaladejo P et al. Moving towards green anaesthesia: Are patient safety and environmentally friendly practices compatible? A focus on single-use devices Anaesth Crit Care Pain Med 2021; 40: 100907. doi:10.1016/j.accpm.2021.100907

[124] Kethu SR, Adler DG. ASGE Technology Committee. et al. ERCP cannulation and sphincterotomy devices. Gastrointest Endosc 2010; 71: 435–445. doi:10.1016/j.gie.2009.07.038

[125] Muscarella LF. Inconsistencies in endoscope-reprocessing and infection-control guidelines: the importance of endoscope drying. Am J Gastroenterol 2006; 101: 2147–2154. doi:10.1111/j.1572-0241.2006.00712.x

[126] Beilenhoff U, Biering H, Blum R et al. Prevention of multidrug-resistant infections from contaminated duodenoscopes: Position Statement of the European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology Nurses and Associates (ESGENA). Endoscopy 2017; 49: 1098–1106. doi:10.1055/s-0043-120523

[127] Fraser TG, Reiner S, Malczynski M et al. Multidrug-resistant Pseudomonas aeruginosa cholangitis after endoscopic retrograde cholangiopancreatography: failure of routine endoscope cultures to prevent an outbreak. Infect Control Hosp Epidemiol 2004; 25: 856–859. doi:10.1086/502309

[128] Saleem N, Ismail MK, Tombazzi CR et al. Endoscopic transmission of carbapenem-resistant Enterobacteriaceae: implications for U.S. Food and Drug Administration approval and postmarket surveillance of endoscopic devices. Gastrointest Endosc 2021; 93: 231–238. doi:10.1016/j.gie.2020.07.061

[129] Thiel CL, Woods NC, Bilec MM. Strategies to reduce greenhouse gas emissions from laparoscopic surgery. Am J Public Health 2018; 108: S158–S164. doi:10.2105/AJPH.2018.304397

[130] Kinney TP, Kozarek RA, Raltz S et al. Contamination of single-use biopsy forceps: a prospective in vitro analysis. Gastrointest Endosc 2002; 56: 209–212. doi:10.1016/s0016-5107(02)70179-x

[131] European Commission. Public Health. National rules on reprocessing of single-use devices. Accessed: 1 Mar 2022 at: https://ec.europa.eu/health/medical-devices-new-regulations/getting-ready-new-regulations/national-rules-reprocessing-single-use-devices_en

[132] Casini B, Pan A, Guarini A et al. Multisocieties position paper: Microbiological surveillance on flexible endoscopes. Dig Liver Dis 2021; 53: 1105–1111. doi:10.1016/j.dld.2021.06.016

[133] Ng FH, Wong SY, Lai ST et al. Reloading a variceal rubber band ligator with hemorrhoidal bands: an inexpensive and effective method. Endoscopy 1997; 29: 233. doi:10.1055/s-2007-1004181

[134] Calderwood AH, Day LW. ASGE Quality Assurance in Endoscopy Committee. et al. ASGE guideline for infection control during GI endoscopy. Gastrointest Endosc 2018; 87: 1167–1179. doi:10.1016/j.gie.2017.12.009

[135] Kovaleva J, Peters FTM, van der Mei HC et al. Transmission of infection by flexible gastrointestinal endoscopy and bronchoscopy. Clin Microbiol Rev 2013; 26: 231–254. doi:10.1128/CMR.00085-12

[136] American Gastroenterological Association. FDA transition to disposable component duodenoscopes – talking points for your patients. September 18, 2019. Accessed: 18 January 2022 at: https://gastro.org/news/fda-transition-to-disposable-component-duodenoscopes-talking-points-for-your-patients

[137] Barakat MT, Ghosh S, Banerjee S. Cost utility analysis of strategies for minimizing risk of duodenoscope related infections. Gastrointest Endosc 2022; 95: 929–938. doi:10.1016/j.gie.2022.01.002

[138] Travis HS, Ehlers LH, Thornton J. The total cost of reusable duodenoscopes – are single-use duodenoscopes the future of ERCP? Pharmacoeconomics 2020; 5: 1–3. doi:10.37421/pe.2020.5.125

[139] Das A, Cangelosi MJ, Muthusamy VR. . A cost-effectiveness analysis of EXALT model-D single-use duodenoscope versus current duodenoscope reprocessing methods. Techn Innov Gastrointest Endosc 2021: doi:10.1016/j.tige.2021.09.007

[140] Lockhart PB, Brennan MT, Sasser HC et al. Bacteremia associated with toothbrushing and dental extraction. Circulation 2008; 117: 3118–3125. doi:10.1161/CIRCULATIONAHA.107.758524

[141] Balan GG, Sfarti CV, Chiriac SA et al. Duodenoscope-associated infections: a review. Eur J Clin Microbiol Infect Dis 2019; 38: 2205–2213. doi:10.1007/s10096-019-03671-3

[142] Kwakman JA, Erler NS, Vos MC et al. Risk evaluation of duodenoscope-associated infections in the Netherlands calls for a heightened awareness of device-related infections: a systematic review. Endoscopy 2022; 54: 148–155. doi:10.1055/a-1467-6294

[143] Ofstead CL, Heymann OL, Quick MR et al. Residual moisture and waterborne pathogens inside flexible endoscopes: Evidence from a multisite study of endoscope drying effectiveness. Am J Infect Control 2018; 46: 689–696. doi:10.1016/j.ajic.2018.03.002

[144] Agrawal D, Tang Z. Sustainability of single-use endoscopes. Techn Innov Gastrointest Endosc 2021; 23: 353–362. doi:10.1016/j.tige.2021.06.001

[145] Kenters N, Tartari E, Hopman J et al. Worldwide practices on flexible endoscope reprocessing. Antimicrob Resist Infect Control 2018; 7: 153. doi:10.1186/s13756-018-0446-6

[146] Musu M, Lai A, Mereu NM et al. Assessing hand hygiene compliance among healthcare workers in six intensive care units. J Prev Med Hyg 2017; 58: E231–E237

[147] Holzwanger EA, Bilal M, Saperia J et al. Duodenoscope-related infections and potential role of single-use duodenoscopes. VideoGIE 2020; 5: 628–629. doi:10.1016/j.vgie.2020.08.011

[148] Trindade AJ, Copland A, Bhatt A et al. Single-use duodenoscopes and duodenoscopes with disposable end caps. Gastrointest Endosc 2021; 93: 997–1005. doi:10.1016/j.gie.2020.12.033

[149] Sahakian AB, Siddiqui UD. Single-use duodenoscopes: The next disruptor or passing fad? Gastrointest Endosc 2021; 94: 1056–1058. doi:10.1016/j.gie.2021.08.010

[150] Sahu DK, Basadonna G. Health economic savings of single use flexible endoscopes vs current re-usable endoscopes and disposable sheath systems. SAGES Abstract Archives. Accessed: 30 Jan 2022 at: https://www.sages.org/meetings/annual-meeting/abstracts-archive/health-economic-savings-of-single-use-flexible-endoscopes-vs-current-re-usable-endoscopes-and-disposable-sheath-systems

[151] Napoléon B, Gonzalez J-M, Grandval P et al. Evaluation of the performances of a single-use duodenoscope: Prospective multi-center national study. Dig Endosc 2022; 34: 215–221. doi:10.1111/den.13965

[152] Lisotti A, Zagari RM, Fusaroli P et al. Optimal safety and pooled technical success rate for ERCP performed with single-use duodenoscopes. Dig Liver Dis 2021: doi:10.1016/j.dld.2021.11.003

[153] Muthusamy VR, Bruno MJ, Kozarek RA et al. Clinical evaluation of a single-use duodenoscope for endoscopic retrograde cholangiopancreatography. Clin Gastroenterol Hepatol 2020; 18: 2108–2117.e3. doi:10.1016/j.cgh.2019.10.052

[154] Ross AS, Bruno MJ, Kozarek RA et al. Novel single-use duodenoscope compared with 3 models of reusable duodenoscopes for ERCP: a randomized bench-model comparison. Gastrointest Endosc 2020; 91: 396–403. doi:10.1016/j.gie.2019.08.032

[155] Bang JY, Hawes R, Varadarajulu S. Equivalent performance of single-use and reusable duodenoscopes in a randomised trial. Gut 2021; 70: 838–844. doi:10.1136/gutjnl-2020-321836

[156] Slivka A, Ross AS, Sejpal DV et al. Single-use duodenoscope for ERCP performed by endoscopists with a range of experience in procedures of variable complexity. Gastrointest Endosc 2021; 94: 1046–1055. doi:10.1016/j.gie.2021.06.017

[157] Martínez-Ortega A, Albillos A, Vázquez-Sequeiros E. A new single-use disposable duodenoscope (EXALTTMModel D) for the treatment of an anastomotic biliary stenosis in a liver transplant patient. Rev Esp Enferm Dig 2021: doi:10.17235/reed.2021.8201/2021

[158] Foo C-C, Leung W-K, Lui TK-L et al. Feasibility study of a single-use balloon-assisted robotic colonoscope in healthy volunteers. Endosc Int Open 2021; 9: E537–E542. doi:10.1055/a-1352-3688

[159] Rösch T, Adler A, Pohl H et al. A motor-driven single-use colonoscope controlled with a hand-held device: a feasibility study in volunteers. Gastrointest Endosc 2008; 67: 1139–1146. doi:10.1016/j.gie.2007.10.065

[160] Ciocîrlan M. Low-cost disposable endoscope: pros and cons. Endosc Int Open 2019; 7: E1184–E1186. doi:10.1055/a-0959-6003

[161] Li D-F, Shi R-Y, Tian Y-H et al. The feasibility and safety of disposable endoscope vs. conventional endoscope for upper gastrointestinal tract examination: a multicenter, randomized, parallel, non-inferiority trial. Z Gastroenterol 2021: doi:10.1055/a-1555-0568

[162] Shoup T. As low as reasonably practicable: An approach to managing device risk. Biomed Instrum Technol 2018; 52: 248. doi:10.2345/0899-8205-52.3.248

[163] Gandhi V, Al-Hadithy N, Göpfert A et al. Integrating sustainability into postgraduate medical education. Future Healthc J 2020; 7: 102–104. doi:10.7861/fhj.2020-0042

[164] Shaw E, Walpole S, McLean M et al. AMEE Consensus Statement: Planetary health and education for sustainable healthcare. Med Teach 2021; 43: 272–286. doi:10.1080/0142159X.2020.1860207

[165] Park KY, Russell JI, Wilke NP et al. Reducing cost and waste in pediatric laparoscopic procedures. J Pediatr Surg 2021; 56: 66–70. doi:10.1016/j.jpedsurg.2020.09.052

[166] Depew WT, Hookey LC, Vanner SJ et al. Opportunity costs of gastrointestinal endoscopic training in Canada. Can J Gastroenterol 2010; 24: 733–738. doi:10.1155/2010/304689

[167] McCashland T, Brand R, Lyden E et al. The time and financial impact of training fellows in endoscopy. CORI Research Project. Clinical Outcomes Research Initiative. Am J Gastroenterol 2000; 95: 3129–3132. doi:10.1111/j.1572-0241.2000.03280.x

[168] Blackburn SC, Griffin SJ. Role of simulation in training the next generation of endoscopists. World J Gastrointest Endosc 2014; 6: 234–239. doi:10.4253/wjge.v6.i6.234

[169] Goodman AJ, Melson J. ASGE Technology Committee. et al. Endoscopic simulators. Gastrointest Endosc 2019; 90: 1–12. doi:10.1016/j.gie.2018.10.037

[170] Valenti A, Fortuna G, Barillari C et al. The future of scientific conferences in the era of the COVID-19 pandemic: Critical analysis and future perspectives. Ind Health 2021; 59: 334–339. doi:10.2486/indhealth.2021-0102

[171] Duane B, Lyne A, Faulkner T et al. Webinars reduce the environmental footprint of pediatric cardiology conferences. Cardiol Young 2021; 31: 1625–1632. doi:10.1017/S1047951121000718

[172] Webster GJ, El Menabawey T, Arvanitakis M et al. Live endoscopy events (LEEs): European Society of Gastrointestinal Endoscopy Position Statement – Update 2021. Endoscopy 2021; 53: 842–849. doi:10.1055/a-1511-1657

[173] Bisschops R, Rutter MD, Areia M et al. Overcoming the barriers to dissemination and implementation of quality measures for gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) and United European Gastroenterology (UEG) position statement. Endoscopy 2021; 53: 196–202. doi:10.1055/a-1312-6389

[174] Kaminski MF, Thomas-Gibson S, Bugajski M et al. Performance measures for lower gastrointestinal endoscopy: a European Society of Gastrointestinal Endoscopy (ESGE) Quality Improvement Initiative. Endoscopy 2017; 49: 378–397. doi:10.1055/s-0043-103411

[175] Bisschops R, Areia M, Coron E et al. Performance measures for upper gastrointestinal endoscopy: a European Society of Gastrointestinal Endoscopy (ESGE) Quality Improvement Initiative. Endoscopy 2016; 48: 843–864. doi:10.1055/s-0042-113128

[176] Domagk D, Oppong KW, Aabakken L et al. Performance measures for ERCP and endoscopic ultrasound: a European Society of Gastrointestinal Endoscopy (ESGE) Quality Improvement Initiative. Endoscopy 2018; 50: 1116–1127. doi:10.1055/a-0749-8767

[177] Sinonquel P, Eelbode T, Bossuyt P et al. Artificial intelligence and its impact on quality improvement in upper and lower gastrointestinal endoscopy. Dig Endosc 2021; 33: 242–253. doi:10.1111/den.13888

[178] Wu L, Zhang J, Zhou W et al. Randomised controlled trial of WISENSE, a real-time quality improving system for monitoring blind spots during esophagogastroduodenoscopy. Gut 2019; 68: 2161–2169. doi:10.1136/gutjnl-2018-317366

[179] Bretthauer M, Aabakken L, Dekker E et al. Requirements and standards facilitating quality improvement for reporting systems in gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement. Endoscopy 2016; 48: 291–294. doi:10.1055/s-0042-100186

[180] Lyle K, Dent L, Bailey S et al. Carbon cost of pragmatic randomised controlled trials: retrospective analysis of sample of trials. BMJ 2009; 339: b4187. doi:10.1136/bmj.b4187

[181] Adshead F, Al-Shahi Salman R, Aumonier S et al. A strategy to reduce the carbon footprint of clinical trials. Lancet 2021; 398: 281–282. doi:10.1016/S0140-6736(21)01384-2

[182] Tiseo I. Switzerland: carbon dioxide emissions 1970-2020. Statista. Accessed: 20 Jan 2022 at: https://www.statista.com/statistics/449824/co2-emissions-switzerland/

[183] Ligozat A-L, Névéol A, Daly B et al. Ten simple rules to make your research more sustainable. PLoS Comput Biol 2020; 16: e1008148. doi:10.1371/journal.pcbi.1008148

[184] Sustainable Trials Study Group. Towards sustainable clinical trials. BMJ 2007; 334: 671–673. doi:10.1136/bmj.39140.623137.BE

[185] National Institute for Health and Care Research (NIHR) Carbon reduction guidelines. 30 Jul 2019. Accessed: 03 Dec 2021 at: https://www.nihr.ac.uk/documents/the-nihr-carbon-reduction-guidelines/21685

[186] Pioche M, Lambin T, Rivory J. Let's urgently engage ourselves in "greening" endoscopy to address ecological issues! Endosc Int Open 2021; 9: E1752–E1753. doi:10.1055/a-1546-8975

[187] Wu S, Cerceo E. Sustainability initiatives in the operating room. Jt Comm J Qual Patient Saf 2021; 47: 663–672. doi:10.1016/j.jcjq.2021.06.010

[188] Agache I, Sampath V, Aguilera J et al. Climate change and global health: a call to more research and more action. Allergy 2022: 1389–1407. doi:10.1111/all.15229

[189] Thiel CL, Schehlein E, Ravilla T et al. Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility. J Cataract Refract Surg 2017; 43: 1391–1398. doi:10.1016/j.jcrs.2017.08.017

[190] Tauber J, Chinwuba I, Kleyn D et al. Quantification of the cost and potential environmental effects of unused pharmaceutical products in cataract surgery. JAMA Ophthalmol 2019: 1156–1163. doi:10.1001/jamaophthalmol.2019.2901

[191] Johansson M, Bero L, Bonfill X et al. Cochrane Sustainable Healthcare: evidence for action on too much medicine. Cochrane Database Syst Rev 2019; 12: ED000143. doi:10.1002/14651858.ED000143

[192] Andrews JC, Schünemann HJ, Oxman AD et al. GRADE guidelines: 15. Going from evidence to recommendation – determinants of a recommendation's direction and strength. J Clin Epidemiol 2013; 66: 726–735. doi:10.1016/j.jclinepi.2013.02.003

[193] European Commission. Climate Action. European Green Deal. Accessed: 13 Dec 2021 at: https://ec.europa.eu/clima/eu-action/european-green-deal_en

[194] United Nations Global Compact. The power of principles. The Ten Principles of the UN Global Compact. Accessed: 13 Dec 2021 at: https://www.unglobalcompact.org/what-is-gc/mission/principles

[195] United Nations Global Compact. The world's largest corporate sustainability initiative. Accessed: 13 Dec 2021 at: https://www.unglobalcompact.org/what-is-gc

[196] Zeng T, Deschênes J, Durif F. Eco-design packaging: An epistemological analysis and transformative research agenda. J Clean Prod 2020; 276: 123361. doi:10.1016/j.jclepro.2020.123361

[197] United Nations Carbon Offset Platform. What is offsetting? Accessed: 14 Dec 2021 at: https://offset.climateneutralnow.org/aboutoffsetting

[198] Joshi NP, Stahnisch FW, Noseworthy TW. Reassessment of health technologies: Obsolescence and waste. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2009: http://dx.doi.org/10.11575/PRISM/33622

[199] Biomedical Engineering Advisory Group. Life span of biomedical devices. Accessed: 03 Dec 2021 at: http://cedglobal.org/download/Life%20Span%20of%20Biomedical%20Devices%20-%20Guidance%20Paper%20Final.pdf

[200] The Health Foundation. Public perceptions of climate change and health (September 2021). Accessed: 5 March 2022 at: https://www.health.org.uk/publications/public-perceptions-of-climate-change-and-health-september-2021

[201] European Commission. Climate Action. Transport emissions. Accessed: 26 Feb 2022 at: https://ec.europa.eu/clima/eu-action/transport-emissions_en

[202] World Health Organization. Patient empowerment and health care. 2009. https://www.ncbi.nlm.nih.gov/books/NBK144022/

[203] Pekonen A, Eloranta S, Stolt M et al. Measuring patient empowerment – A systematic review. Patient Educ Couns 2020; 103: 777–787. doi:10.1016/j.pec.2019.10.019

[204] Kambhampati S, Ashvetiya T, Stone NJ et al. Shared decision-making and patient empowerment in preventive cardiology. Curr Cardiol Rep 2016; 18: 49. doi:10.1007/s11886-016-0729-6

[205] European Commission. Climate Action. 2050 long-term strategy. Accessed: 26 Feb 2022 at: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2050-long-term-strategy_en

[206] Hassan C, Ponchon T, Bisschops R et al. European Society of Gastrointestinal Endoscopy (ESGE) Publications Policy – Update 2020. Endoscopy 2020; 52: 123–126. doi:10.1055/a-1067-4657

