Memorandum

To: **NZAGS Executive**

From: **David Moss, Chair AoNZ Committee in General Surgery**

Date: **12 July 2023**

Re: **Sustainable operating environments**

Attached for review are the Intercollegiate Green Theatre Checklist and British Society of Gastroenterology joint consensus on practical measures for environmental sustainability in endoscopy.

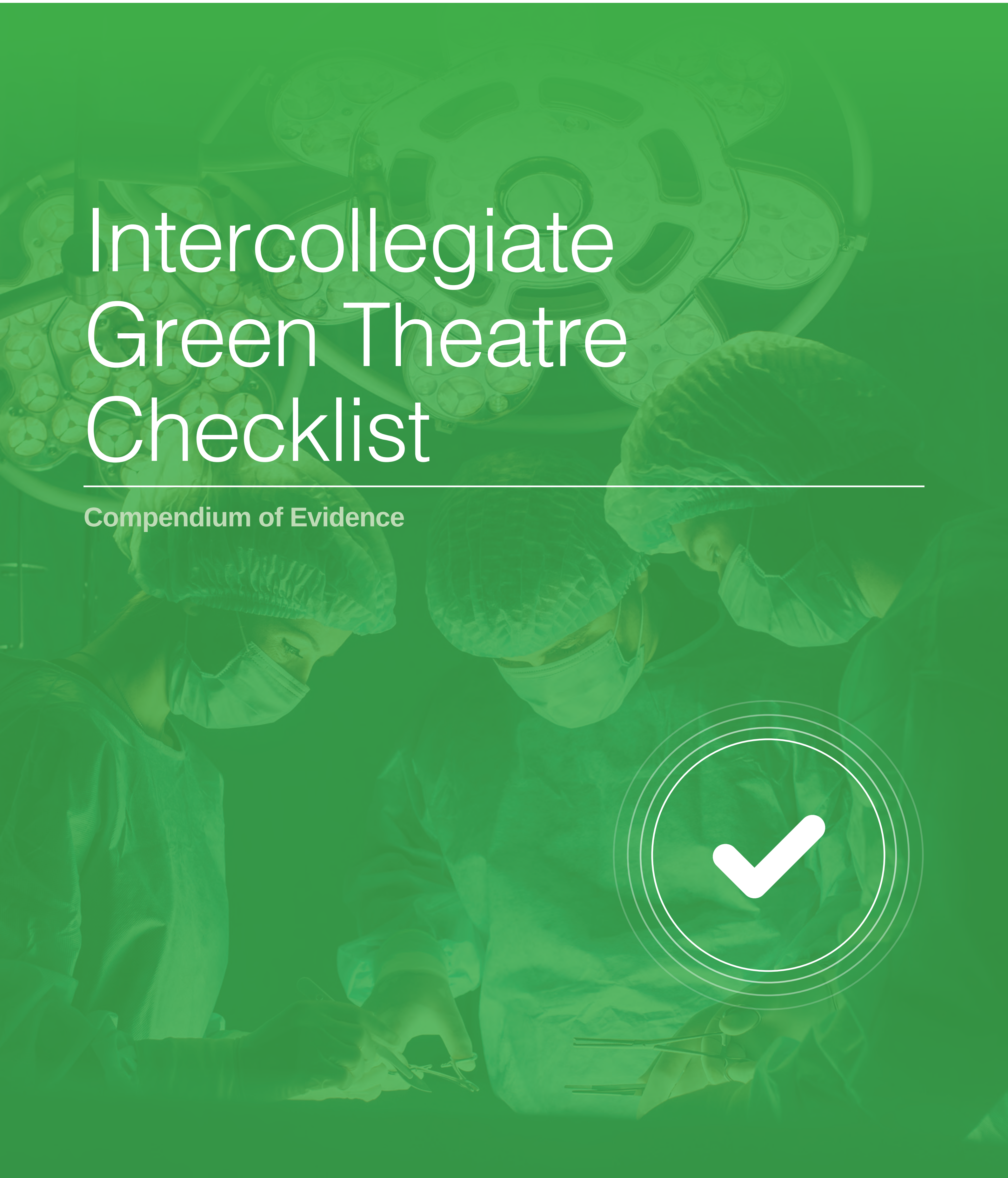
These were presented to the Committee in General Surgery by David Fletcher, RACS Council Liaison, with the view that these measures should be in place in all operating environments.

The Committee fully supports this view and requests a position statement from the NZAGS Executive.

The Royal College of Surgeons of Edinburgh

Royal College of Surgeons of England – Advancing Surgical Care

Royal College of Physicians and Surgeons of Glasgow



Intercollegiate Green Theatre Checklist

Compendium of Evidence

Welcome to the Intercollegiate Green Theatre Checklist Compendium of Evidence

According to the World Health Organisation, humanity faces its greatest ever threat: the climate and ecological crisis. Health care services globally have a large carbon footprint, accounting for 4-5% of total carbon emissions.[1] Surgery is particularly carbon intensive, with a typical single operation estimated to generate between 150-170 kgCO2e, equivalent to driving 450 miles in an average petrol car.[2]

The UK and Ireland surgical colleges have recognised that it is imperative for us to act collectively and urgently to address this issue. Here we present a compendium of peer-reviewed evidence, guidelines and policies that inform the interventions included in the Intercollegiate Green Theatre Checklist. This compendium should support members of the surgical team to introduce changes in their own operating departments. Our recommendations apply the principles of sustainable quality improvement in healthcare, which aim to achieve the "triple bottom line" of environmental, social and economic impacts.[3]

This is an emerging field, and therefore this is an iterative document that will evolve with new evidence.

How to use the checklist:

The checklist is divided into four sections, the first dedicated to anaesthetic care, and the subsequent three looking at preparation for surgery, intra-operative practice and post-operative measures.

We suggest the checklist is initially used at the daily brief at the start of an operating list, as an aide-memoire for the team of the modifications that could be applied there and then. Once these practices become embedded into practice, then the checklist may be used less frequently. At present, some theatres will lack the infrastructure required to enact all the suggested interventions and so the checklist can serve as a roadmap for discussion with management, or at departmental meetings, to guide required changes. Finally, if completed regularly, the checklist could also be used as a scorecard to monitor progress.

However you choose to use the checklist, we hope that it will be a valuable tool for staff to identify and understand interventions and considerations to decrease the environmental impact of their work.

We are grateful for feedback and any information on new research and developments, so please do contact us at sustainability@rcsed.ac.uk sustainability@rcseng.ac.uk or by using the Contact us form on the colleges' Sustainability webpages.

General Principles for Greener Surgical Care Pathways

Although this checklist focuses on the operating theatre alone, there are a number of other interventions that can be introduced along the whole surgical patient pathway. The biggest way to reduce the carbon footprint of surgery is primary prevention of surgical disease. The first principle of sustainable surgery is therefore health promotion and disease prevention/optimisation through lifestyle changes, dietary advice, patient education and patient empowerment.[4]

It is important to note however, that surgery in itself may actually be less environmentally impactful (as well as more economical) than conservative or medical management of certain chronic conditions.[5]

When surgery is necessary, the whole pathway should be rationalised and streamlined, including utilising virtual consultations, one-stop clinics, diagnostic hubs, daycase surgery,[6] whenever possible and clinically appropriate.

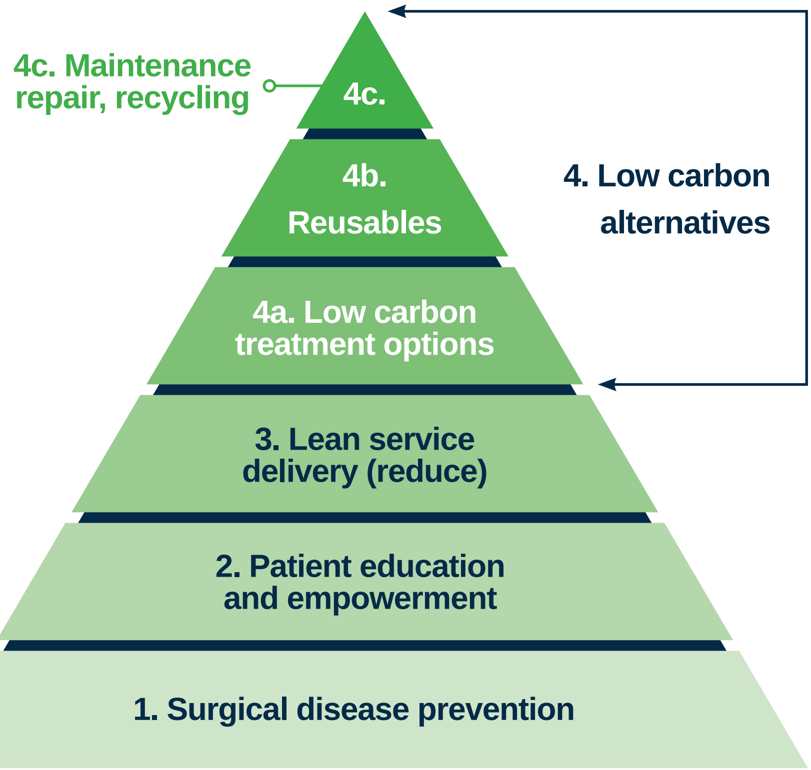


Figure 1. Principles of sustainability in healthcare.[4]

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THE ROYAL COLLEGE OF SURGEONS OF EDINBURGH

Royal College of Surgeons of England
ADVANCING SURGICAL CARE

ROYAL COLLEGE OF PHYSICIANS AND SURGEONS OF GLASGOW

Intercollegiate Green Theatre Checklist

Below are a list of recommendations to reduce the environmental impact of operating theatres. All the relevant guidance and published evidence has been included in the Compendium of evidence, accessed via the QR code:

Anaesthesia

1 Consider local/regional anaesthesia where appropriate (with targeted O_2 delivery only if necessary)

2 Use TIVA whenever possible with high fresh gas flows (5-6 L) and, if appropriate, a low O_2 concentration

3 Limit Nitrous Oxide (N_2O) to specific cases only and if using:
- check N_2O pipes for leaks or consider decommissioning the manifold and switching to cylinders at point of use;
- introduce N_2O crackers for patient-controlled delivery.

4 If using inhalational anaesthesia:
- use lowest global warming potential (sevoflurane better than isoflurane better than desflurane);
- consider removing desflurane from formulary;
- use low-flow target controlled anaesthetic machines;
- consider Volatile Capture Technology.

5 Switch to reusable equipment (e.g. laryngoscopes, underbody heaters, slide sheets, trays)

6 Minimise drug waste (“*Don’t open it unless you need it”,* pre-empt propofol use)

Preparing for Surgery

7 Switch to reusable textiles, including theatre hats, sterile gowns, patient drapes, and trolley covers

8 Reduce water and energy consumption:
- rub don’t scrub: after first water scrub of day, you can use alcohol rub for subsequent cases;
- install automatic or pedal-controlled water taps.

9 Avoid clinically unnecessary interventions (e.g. antibiotics, catheterisation, histological examinations)

Intraoperative Equipment

10 REVIEW & RATIONALISE:
- surgeon preference lists for each operation - separate essential vs. optional items to have ready on side;
- single-use surgical packs - what can be reusable and added to instrument sets? what is surplus? (request suppliers remove these);
- instrument sets - open only what and when needed, integrate supplementary items into sets, and consolidate sets only if it allows smaller/fewer sets (please see guidance).

11 REDUCE: avoid all unnecessary equipment (eg swabs, single-use gloves), “*Don’t open it unless you need it”*

12 REUSE: opt for reusables, hybrid, or remanufactured equipment instead of single-use (e.g. diathermy, gallipots, kidney-dishes, light handles, quivers, staplers, energy devices)

13 REPLACE: switch to low carbon alternatives (e.g. skin sutures vs. clips, loose prep in gallipots)

After the Operation

14 RECYCLE or use lowest carbon appropriate waste streams as appropriate:
- use domestic or recycling waste streams for all packaging;
- use non-infectious offensive waste (yellow/black tiger), unless clear risk of infection;
- ensure only appropriate contents in sharps bins (sharps/drugs);
- arrange metals/battery collection where possible.

15 REPAIR: ensure damaged reusable equipment is repaired, encourage active maintenance

16 POWER OFF: lights, computers, ventilation, AGSS, temperature control when theatre empty

DISCLAIMER: These suggestions are based upon current evidence and broadly generisable, however, specific environmental impacts will depend upon local infrastructure and individual Trusts’ implementation strategies.

Anaesthesia

Anaesthetic gases contribute an estimated 2% of the NHS's total carbon emissions.[7] All volatile anaesthetic agents are potent Greenhouse Gases, with desflurane and nitrous oxide having by far the highest global warming potential (GWP).[8] In addition to its high GWP, nitrous oxide also contributes directly to the destruction of the ozone layer.[9]

Use of Local/Regional Anaesthesia

A range of common surgical operations, such as inguinal hernia repair, hip and knee arthroplasty, can be performed safely under local (LA) or regional anaesthesia (RA) with considerable clinical benefits for patients.[10-12] In addition, regional and local anaesthesia is usually environmentally preferable, both through negating the extra resources required for general anaesthesia (GA) (such as volatile anaesthetic agents and environmentally persistent intravenous drugs[13]) but also because of the associated shortened patient stay,[10-14] which reduces individual patient resource consumption and improves efficiency in theatres, in turn improving environmental impacts.

Conservative Oxygen (O_2) Therapy

When patients are undergoing procedures under RA, or are in the recovery room, it is best to titrate O_2 flow rates to target appropriate saturation levels. Excess O_2 is detrimental to patients,[15] but also has its own carbon footprint, with 1 L medical O_2 equivalent to 0.7 $kgCO_2e$.[16] When utilising high flows, it is also important to note that whilst standard O_2 flow meters appear to have a maximum flow rate of 15 L/min, when the valve is opened fully they can deliver up to 75 L/min,[17] which wastes hospital oxygen stores with no benefit to patients.

Use Total Intra-Venous Anaesthesia (TIVA) When Possible

TIVA has a reduced GWP compared to volatile anaesthetic agents; however the biotoxic and water contamination effects of anaesthetic compounds remain to be clarified.[18] In the absence of inhalational anaesthetic agents, remember to increase fresh gas flow (FGF) to 6 L/min in order to reduce carbon dioxide (CO_2) absorbent consumption, with associated environmental and financial benefits.[19,20]

Limit Nitrous Oxide (N_2O) Use and Waste

N_2O has a similar carbon footprint to desflurane at clinically-equivalent doses.[21] Its avoidance, both to support fresh gas flow delivery and in the form of Entonox, has been described as the "largest contribution to reducing anaesthetic greenhouse gas emissions".[22]

- *Use for specific cases only:*

  Anaesthetic use of N_2O is only recommended for paediatric inductions and Caesarean Sections under GA.

- *Check N_2O pipes for leaks or consider decommissioning the manifold and switching to cylinders at point of use:*

  N_2O manifolds for theatres should be decommissioned and replaced with local cylinders to combat widespread issues with pipeline and manifold leakage, as well as stock control (guidance for decommissioning can be found on the Association of Anaesthetists' Nitrous Oxide project page).[23]

- *Introduce N_2O crackers for patient-controlled delivery:*

  Use of Entonox or pure *N_2O* in other areas of the hospital or healthcare services (Dental, Emergency Department, Endoscopy, Maternity, Ambulance) should be examined. Alternatives, including *N_2O* crackers, should be sought where clinically appropriate.

Anaesthesia
(Continued...)

If Using Inhalation Anaesthesia

- *Use lowest global warming potential:*

  Amongst anaesthetic gases, desflurane has the highest environmental impact, followed by isoflurane, and lastly sevoflurane and halothane.[24]

Agent	$KgCO_2e$ of vaporised bottle of the agent	GWP_{100}
Nitrous oxide	1013 (Size E cylinder 3.4 kg)	298
Sevoflurane	49 (250 ml)	130
Isoflurane	190 (250 ml)	510
Desflurane	886 (240 ml)	2540

Table 1 - Greenhouse Warming Potential over 100 year time horizon (GWP100) and Carbon dioxide equivalency (CO2e) of anaesthetic gases.

At low fresh gas flows (0.5 L/min) and equipotent levels (1 MAC of agent), desflurane anaesthesia has a carbon footprint equivalent to driving 133 km; whereas sevoflurane has a carbon footprint equivalent to driving 2 km (calculated using the Association of Anaesthetists Anaesthetic gases calculator).[25] At higher fresh gas flows, these carbon footprints increase in direct proportion.[24]

- *Consider removing desflurane from formulary:*

  Although desflurane was previously associated with very limited reductions in emergence time (1-2 minutes),[26] a recent publication has suggested that these effects are not clinically significant nor do they justify the increase in financial and environmental costs.[27] The NHS has introduced guidance asking all trusts to reduce desflurane use to less than 5% of their total volume of anaesthetic gases.[28]

- *Use low flows target-controlled anaesthetic machines*

  This has been shown to help preserve resources as well as reduce the environmental impact of an anaesthetic.[29,30]

- *Consider volatile capture technology (VCT):*

  VCT utilises carbon filters to capture molecules of volatile agents after they have been expired by the patient, before they are released unmitigated into the atmosphere. VCT is connected in series to the anaesthetic machine's Anaesthetic Gas Scavenging Systems (AGSS) output and can capture between 25 to 70% of the total volatile volume administered to a patient.[16,31] Using VCT in addition to a carrier mix of O_2/air at the lowest flow rate is thought to have lower environmental impact when compared to propofol.[16]

Switch to Reusable Anaesthetic Equipment where Possible

Using reusable anaesthetic equipment (such as supraglottic airways,[32] laryngoscopes,[33] direct-contact heaters, slide sheets, drug trays), can not only provide cost savings but also reduce the anaesthetic carbon footprint by as much as 84%.[34]

- *Reusable direct-contact heaters:*

  Consideration as to whether warming devices are needed routinely for all operations should be taken.[35] For brief operations, single-use warming devices may not be needed at all (similar to single-use Deep Venous Thrombosis prophylaxis stockings and air-compression devices).

  If warming is needed, then it may be more cost effective and more environmentally friendly to use reusable direct-contact heaters.

  NICE guidance from 2011 suggested that direct-body heaters are equivalent to other devices for prevention of intraoperative hypothermia.[36] Direct-contact heaters are reusable, energy efficient,[37] easily cleaned and relatively silent, and have been promoted as a more cost-effective and practical alternative to forced-air warming.[38]

Anaesthesia
(Continued...)

Minimise Drug Waste

Pharmaceuticals make up 20% of total NHS England emissions.[39]

- *Don't open it unless you need it!:*

  Anaesthetic drug waste was estimated to cost $185,250 (~£148,000) per year in one USA institution alone[40], approximately equivalent to 51,700 kgCO_2e/year. Drug waste represents up to 26% of the entire anaesthesia drug budget,[41] and includes pre-emptive emergency drugs (e.g. metaraminol, suxamethonium, atropine) which are wasted in between 39% to 91% of cases.[42]

- *Reduce propofol waste:*

  Multidose vial drugs are also a large source of waste, with propofol alone accounting for up to 50% of all anaesthetic drug waste.[40,43] Removing larger vials of propofol, accurately estimating required propofol doses (through freely available online calculators and apps), drawing up as and when required, and introducing prefilled drug syringes, have been suggested as a cost-saving and more environmentally sustainable options.[40,42-44]

Preparing for Surgery

Reusable Theatre Textiles

- *Theatre hats:*

  Multiple studies have demonstrated no difference in Surgical Site Infections (SSIs) with disposable bouffant caps compared to traditional, reusable cloth caps.[45-48] Reusable caps are more cost efficient in the long run.[48]

  To date no studies have compared theatre headwear from an environmental perspective, but other reusable theatre wear has been shown to be more sustainable.[49]

  Reusable hats are acceptable theatre wear according to NHS guidelines,[50,51] and can be personalised with names and roles to improve team communication.[52]

- *Reusable gowns:*

  Single-use surgical gowns produce huge amounts of waste, with over 36 million used in NHS England in 2020 alone.[53] Compared to disposable gowns, reusable gowns reduce carbon emissions by 200-300%, water usage by 250-330% and solid waste by 750%.[54,55] A Life Cycle Analysis (LCA) estimated a saving of almost 1.1 kgCO_2e per gown when substituting disposable gowns with reusable gowns.[54]

  There is no evidence that reusable gowns increase SSIs,[56] and in fact reusable gowns usually offer better protection due to superior water resistance and durability.[57] Another way to make financial as well as environmental savings is to use the correct gown: reinforced gowns require more materials to produce and lead to more waste and are only needed when there is expected exposure to very high volumes of fluid.

- *Drapes:*

  When evaluating the risk of SSIs with different types of drapes, there is no evidence that single-use drapes are better than reusable.[58] Erroneous beliefs in relation to surgical drapes are often based on historical textiles (such as cotton) that are no longer in use and were not manufactured nor quality assured to modern requirements. Nowadays to meet stringent UK standards (including EN 13975 and EN ISO 13485), textiles used in surgery undergo thorough quality assessments and strict auditing of material integrity, water penetration, and sterilisation before each use, and throughout their life.[59]

Reduce Water and Energy Consumption

- *Rub don't scrub:*

  NICE guidelines recommend that after the first water-based hand wash of the day, alcohol based hand-rub (ABHR) can be used on clean hands for subsequent antisepsis between surgical cases.[60]

  ABHR achieves hand decontamination for a wide variety of organisms,[61,62] and has been shown to have equal[63] or superior[64-66] efficacy to traditional scrub. ABHR also reduces duration of the decontamination process,[65] and has a favourable user profile,[67] attributed to lower rates of skin irritation and dryness.[68,69]

  Environmentally, studies have demonstrated many litres of water are saved when using ABHR,[70] with one hospital estimating saving 2.7 million litres of water annually by switching to waterless scrub.[71] Financial savings ensue from reduced water use as well as reduced hand towels,[72-74] although actual values will be sensitive to individual practice and local structures for procurement.

Preparing for Surgery
(Continued...)

Avoid Clinically Unnecessary Interventions

- *Antibiotics:*

  Pharmaceuticals contribute a fifth of NHS emissions from procurement.[39] For antibiotics, 30% of prescriptions are in secondary and tertiary care settings.[75] In 2015, 42 billion doses were used every day in the NHS, with this is expected to rise by 200% by 2030.[76] Not only is bacterial antibiotic resistance estimated to account for 1.27 million deaths worldwide per year,[77] but inappropriate disposal methods, both during production and at point of use, also pose significant ecological risks to soil microorganisms and aquatic life.[78] NICE guidance is that antibiotics should only be used in the presence of a surgical implant or where surgery is on a contaminated site.[60]

- *Catheterisation:*

  Single-use catheters have a large environmental impact.[79] It is important to consider whether the catheter is needed in the first place: for short operations, patients can be asked to empty their bladder just before anaesthesia.

  When procuring single-use catheters, consideration should also be given to their composition, with preference given to latex or newer polyolefin-based elastomer catheters with a more environmentally favourable profile compared to materials like PVC or TPU.[79,80]

- *Histological examinations:*

  Histological processing comes with a carbon cost. For example, a single gastrointestinal sample uses 0.29 kgCO_2e, roughly the same as driving a car one km.[81] In addition, little benefit has been found in certain routine elective procedures, such as cholecystectomy.[82] Surgeons should assess the need for histological examinations on a case-by-case basis, considering factors such as clinical uncertainty or consequences for clinical management.

Intraoperative Equipment

REVIEW & RATIONALISE: streamline surgeon preference lists, surgical packs and instrument sets

- *Surgeon preference lists for each operation:*

  Separate what is definitely needed and what can be listed as optional to have ready on side ("*Don't open it unless you need it!*" principle).

- *Single-use surgical pre-prepared packs:*

  Medical equipment contributes 10% of the NHS carbon footprint.[83] Reusable versions of equipment will, in almost every circumstance, reduce carbon footprint,[84] as well as plastic consumption and cost.[85]

  Under contemporary UK policy and practice, sterility of reusable items is assured. Studies from laparoscopic surgery show that disposable instruments carry no advantage for sterility,[86] but also have a 19 fold increase in costs,[87] and at least a four-fold higher carbon footprint.[88]

  Single-use packs often also contain equipment that is not used at all; contacting companies to remove these items all together will reduce financial cost, carbon, and waste.

- *Instrument sets/trays:*

  Unused instruments in an opened instrument tray, known as "overage", lead to significant and rarely justified waste. One department found they could reduce the number of instruments in each tray by 70%, (with an associated 37% reduction in setup time) and estimated institutional annual savings of $2.8 million.[89]

  Because a fixed quantity of resource is used for each sterilisation cycle, sterilisation of each tray takes up part of those resources in proportion to the amount of space it occupies in the autoclave, regardless of the number of instruments on the tray. Optimising loading of trays in the autoclave for each cycle, and optimising number of instruments in each tray, helps to divide these resources over the maximum number of instruments.

  Instruments should therefore be removed from trays but only where these are not used by any surgeons at all, and where consolidation results in a significant reduction in the size of the tray the instruments are housed in.[90] Where instruments are removed and individually wrapped as supplementary items, this significantly increases the carbon footprint (189 gCO2e per individually wrapped instrument vs. 66-77 gCO2e when part of sets).[90] The sterile barrier system (whether metal containers or tray wrap) should also be reused or recycled to confer further carbon reductions.[90]

REDUCE: avoid ALL unnecessary single-use equipment, eg single-use gloves or single-use instruments

- *Don't open it unless you need it!:*

  Operating theatres generate large amounts of waste, compounded by opening but then not using some surgical equipment. Not only does this have financial implications (one study from the US showed an average of $653 of unused equipment per case in neurosurgery),[91] but it needlessly contributes to the surgical carbon footprint. The most common reason for unnecessarily opening supplies is the anticipation of surgeons' needs.[92] Instead of opening equipment 'just in case', it should be opened 'just in time'.

- *Non-sterile single-use gloves:*

  Billions of non-sterile gloves (NSG) are used in the NHS every year,[53] often in circumstances for which they are not required. Studies have found that use of NSG is inappropriate in more than 50% of cases,[93] and could even hinder hand hygiene in 37% of instances due to the potential for cross-contamination.[94]

  NSG are only necessary when there is anticipated contact with bodily fluid, non-intact skin, or mucus membranes, but in some settings it has become habitual to don gloves for almost all patient interactions. This is damaging both to the environment and healthcare professionals' hands. An educational campaign on appropriate use of gloves ('Gloves are Off') at Great Ormond Street hospital, led to use falling by a third.[95]

Intraoperative Equipment
(Continued...)

REUSE: opt for reusable, hybrid or remanufactured equivalents instead of single-use (e.g. diathermy, gallipots, kidney-dishes, quivers, light handles, staplers, energy devices)

Single-use equipment is a major hotspot in surgical operations, with consumables typically contributing 32% of carbon emissions.[83]

The increased carbon footprint of minimally invasive and robotic surgery, as exemplified for hysterectomies, the open/vaginal approach emitting 290 $kgCO_2e$, laparoscopic 560 $kgCO_2e$, and robotic >800 $kgCO_2e$, is accounted for in most part by single-use components.[96] Even hybrid reusable and disposable equipment such as laparoscopic ports, scissors and clip appliers have a carbon footprint that is 75% less than single-use alternatives.[85]

The single-use equipment culture was largely driven by uncertainty in the ability of surgical instruments to transmit the incurable variant Creutzfeldt-Jacob Disease (CJD),[97] at a time when modern decontamination and sterilisation practices did not exist.[98] There is no evidence of superior quality or safety with single-use equipment. By swapping for reusable equivalents, significant environmental savings can be easily found, as demonstrated in a systematic review of operating theatre equipment.[84]

Where reuse is not an option, remanufacture should be considered. This is an important solution for single-use medical devices (SUDs) that can contain complex mechanisms, important critical earth elements and precious metals, and are not amenable to traditional recycling. The remanufacturing process is strictly regulated and includes disassembly, component reprocessing, reassembly, sterilisation and recertification for clinical use. A review by the US Government Accountability Office (GAO) and the Food and Drug Administration (FDA) declared that reprocessed SUDs do not increase adverse events and do not present an elevated risk to patients.[99] In addition to environmental savings, remanufactured device save financial costs, including costs of medical waste disposal.[100]

One life-cycle analysis comparing remanufactured to newly-manufactured electrophysiology catheters demonstrated a >50% reduction in GWP,[101] and other studies have shown reduced GWP through remanufacture of energy devices.[100]

REPLACE: switch for low carbon alternatives (e.g. skin sutures instead of clips, loose prep in gallipots)

- *Sutures instead of skin clips:*

  Because of their weight and complexity, single-use skin staplers have a higher embedded carbon footprint than sutures. Where appropriate, using sutures eliminates the need for staplers as well as clip removers. Using absorbable sutures, or instructing patients to remove their own sutures, eliminates the need for another appointment with a healthcare professional, saving on transport emissions and freeing up healthcare resources and time.

- *Sponge-holders and swabs instead of single-use plastic wands:*

  NICE guidance suggests that “loose” antiseptic solutions poured into reusable gallipots and applied using reusable instruments (e.g. sponge-holders) and swabs, have a reduced environmental impact.[102] A large multinational RCT found no benefit in the use of 2% alcoholic chlorhexidine skin preparation compared to 10% aqueous povidone–iodine for the prevention of SSIs.[103] For these reasons, single-use plastic wands for antisepsis are not recommended.

After the Operation

RECYCLE or use lowest carbon appropriate waste streams

Whilst efforts to reduce consumption and decrease reliance on single-use-item are critical, waste is inevitable. Although waste disposal is estimated to account for <0.1% of a typical operation's carbon footprint, (83) the total waste produced by the NHS is equivalent to that of European countries such as Cyprus or Luxembourg.[104]

Hospital waste in the UK is designated into multiple "waste streams" dependent on suitable methods for disposal. The highest carbon footprint for disposal is high temperature incineration (~1074 kgCO_2e), and the lowest is recycling (~21 kgCO_2e). The choice of waste stream can thus have a 50-fold impact on carbon footprint and is mirrored in financial costs, with incineration being more expensive than the less carbon intensive routes.[105]

- *Use domestic or recycling waste streams for all packaging (before any contamination):*

  Studies have suggested that less than 50% of recyclable materials are segregated appropriately prior to entering operating areas where they have potential for contamination.[106] Although recycling recovers only a fraction of embedded carbon and as a strategy is far inferior to reuse, processing of waste through recycling has the lowest carbon footprint of all waste disposal streams and therefore should be prioritised wherever possible.[105]

- *Use non-infectious offensive waste unless clear risk of infection:*

  As opposed to infectious waste (orange bag), non-infectious offensive waste (yellow and black striped bag) can be disposed of through less environmentally detrimental means, where energy is recovered from waste, and typically will have a reduced environmental impact.[105] Many theatres use an orange bag where a yellow and black striped bag would meet requirements.

- *Ensure only appropriate contents in sharps bins (sharps/drugs as per your local guidelines):*

  Waste in the sharp bin undergoes High Temperature Incineration (HTI) at 1100 degrees Celsius and is the most carbon intensive waste stream. In order to decrease the environmental impact of the incineration process, consider exploring non-plastic or reusable options for sharp bins, such as reusable metal containers or single-use cardboard sharp bins.

- *Arrange the collection of specific materials where possible:*

  There are a number of companies in the UK that specialise in the collection and recycling of healthcare waste. Examples include Guedel airways, surgical masks, any single-use metal (e.g. guidewires, drawing up needles, single-use instruments), as well as critical earth elements in the batteries of digital surgical instruments.

After the Operation
(Continued...)

REPAIR reusable surgical instruments and encourage active maintenance

Where possible reusable equipment should be preferred, and when in use actively maintained. Analyses have shown reusable equipment is often better both financially and environmentally, and repair adds to this.[107] For example, reusable steel scissors were found to have an environmental impact of only 1% of that of disposable steel scissors,[108] and repair reduces the per-use carbon footprint of reusable surgical scissors by an additional fifth (with concomitant cost savings of around one-third).[109] In another study, reusable instruments were found to cumulatively be more cost effective and to help reduce the carbon footprint of minor oculoplastic operations.[110]

Power off lights, computers, ventilation, AGSS, temperature control when theatre empty

Heating, ventilation and air conditioning (HVAC) systems contribute to more than 90% of surgical theatres energy usage.[111] Turning off theatre spaces when unused can cut HVAC energy consumption by up to 50%.[111] Other strategies to reduce electricity usage include light-emitting diode (LED) instead of halogen lights, and adopting occupancy sensors.[112]

Anaesthetic gas scavenging systems (AGSS) and overhead radiant heaters account for 80% of the electrical energy used by anaesthetic equipment and should be switched off in unoccupied operating theatres.[113]

"Set-back" modes are able to maintain minimum background conditions, such as humidity or temperature, when the operating theatre is unoccupied, and are recommended by the Department of Health's Health Technical Memorandum on Specialised ventilation.[114]

More information is available on the Centre for Sustainable Healthcare website: The Anaesthetic Gas Scavenging System (AGSS) project,[115] including an audit tool to help document and manage your own theatre system.

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OPEN ACCESS

Green endoscopy: British Society of Gastroenterology (BSG), Joint Accreditation Group (JAG) and Centre for Sustainable Health (CSH) joint consensus on practical measures for environmental sustainability in endoscopy

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ABSTRACT

GI endoscopy is highly resource-intensive with a significant contribution to greenhouse gas (GHG) emissions and waste generation. Sustainable endoscopy in the context of climate change is now the focus of mainstream discussions between endoscopy providers, units and professional societies. In addition to broader global challenges, there are some specific measures relevant to endoscopy units and their practices, which could significantly reduce environmental impact. Awareness of these issues and guidance on practical interventions to mitigate the carbon footprint of GI endoscopy are lacking. In this consensus, we discuss practical measures to reduce the impact of endoscopy on the environment applicable to endoscopy units and practitioners. Adoption of these measures will facilitate and promote new practices and the evolution of a more sustainable specialty.

INTRODUCTION

The healthcare sector is responsible for 4.4% of total greenhouse gas (GHG) emissions worldwide.[1 2] As a high-throughput specialty, with typical national volumes reaching several million procedures annually,[3 4] endoscopy is held to be the third highest hazardous waste generating department in a hospital, per daily occupied bed (after anaesthetics and paediatrics/intensive care) and the second overall (average monthly) waste generator per clinical procedure after radiology.[5 6] In addition to patient volumes, routine endoscopic procedures incur frequent use of single-use items, resource-heavy decontamination, water consumption, significant demands on administration, patient and staff travel as well as high energy consumption in physical estates.

Based on operational energy usage and plastic waste from endoscopic procedures alone, the estimated carbon footprint of endoscopy in the USA stands at 85 768 metric tonnes of CO_2 emission annually, equivalent to >9 million gallons of gasoline consumed, 94 million pounds of coal burned and 212 million miles driven in an average non-electric car.[6 7]

In the context of reducing the environmental impact of healthcare, there is now considerable interest in the carbon footprint and GHG impact of gastroenterology, hepatology and GI endoscopy practice.[8–11]

There is a need for urgent change, without compromising the patient care, clinical standards or training needs. A high-quality evidence base of the actual carbon footprint of clinical activity and various elements of endoscopic procedures is presently lacking, and while more research needs to be done to generate this evidence, there is recognition that steps need to be taken now to protect our planet.

The National Health Service (NHS) in the UK is one of the first national healthcare systems that has made a policy direction towards net-zero, enshrined in legislation with a pledge to reach this target by 2040, and an 80% reduction by 2028–2032.[12] The recent Conference of Parties Health Programme[13] has recommended initiatives to build climate-resilient health systems and raising awareness through healthcare professionals to advocate change. The British Society of Gastroenterology (BSG), together with partner stakeholder organisations in endoscopic practice, Joint Advisory Group for GI Endoscopy (JAG) and the Centre for Sustainable Healthcare (CSH) recognised the need for a consensus document on pragmatic and practical measures that can be taken to minimise the environmental impact of endoscopy and this paper is the first attempt towards moving to a carbon neutral status for endoscopy practice.

METHODOLOGY

In line with accepted principles, these expert opinion consensus and practice position statements have been developed in an area where there is insufficient scientific evidence to produce formal guidelines. The process was compliant with the BSG guideline advice document.[14] Members of the BSG, JAG and the CSH were invited to participate based on their methodological expertise, publication record, accomplishments or experience in the field and commitment to the project. Invited members were divided into four working groups (WGs) focusing on key thematic and subthematic areas relevant to routine endoscopy practice requiring practical guidance. These areas were identified based on the previous work from the Green Endoscopy Group[15 16] and in line with BSG Strategy on Sustainability.[17] The topics of the WGs were: WG 1—functional organisation of a green endoscopy unit, WG 2—sustainable practice related to the endoscopy procedure, WG 3—sustainability practices related to endoscopy environment and WG 4—sustainable postprocedural practices.

The WG members performed a systematic literature search for each assigned topic with the appropriate keywords/Medical Subject Headings terms using Medline/PubMed, Cochrane database and conference abstracts. Outputs were then used to formulate draft practice position statements with the supporting text and references. The statements were further developed using a Delphi methodology[18] incorporating three successive rounds. The Delphi consensus group, in addition to the WGs, consisted of content and topic experts from members of the BSG Sustainability Committee, BSG Endoscopy Committee and The Clinical Standards and Service Committee.

The first round was web-based with anonymous voting using a custom built survey, using a 5-point scale for each statement, inviting feedback comments, exchange of available evidence and suggestions returned to the individual WGs to be included into the iterative development of the final statements. The second Delphi round was a dedicated web meeting involving all available participants on 21 April 2022, with discussion and revision of statements. A total of 25 current practice positions were accepted when ≥80% of participants agreed to the text of the statements. Statements and recommendations not reaching 80% consensus agreement following three rounds of voting were removed. The final manuscript was drafted for consistency by the three coordinators (SS, ADhar, B'HH) before a final review and approval by all WG participants. The document was then submitted for review to BSG, JAG and CSH for endorsement and approval.

The WGs identified a number of areas where evidence was insufficient to provide recommendations for practice and have incorporated areas where further research is desirable to support best practice guidelines.

Statements

Working group 1: functional organisation of a green endoscopy unit

Practice position statement 1:1

We recommend adherence to relevant professional guidelines to ensure clinical appropriateness for all endoscopic procedures.

Of the 'three Rs' (reduce, reuse, recycle) principles that govern attempts to reduce carbon footprint, reducing unnecessary endoscopy procedures is likely to have a significant impact. It is estimated that up to 56% of referrals for upper GI endoscopies and between 23% and 52% for colonoscopies may be inappropriate.[19 20] Of particular note is the low yield of endoscopic procedures in guiding management of some chronic scenarios such as endoscopy for simple dyspepsia and colonoscopy for constipation.[21] Furthermore, the value of screening and surveillance colonoscopy in average risk populations and in frail elderly or where the screening intervals exceed estimated life expectancy has been challenged.[22 23] Establishing guideline-supported referral pathways, enhanced departmental vetting procedures and regular educational activities to update emerging evidence for appropriate use of endoscopy are steps which endoscopy units can take to ensure the appropriateness of endoscopic procedures.[16 24] While recognising that endoscopy is a key component in the diagnosis and management of GI conditions, conventional diagnostic endoscopy can be replaced by alternative technologies in a number of clinical settings to minimise the number of procedures being carried out. An example of this approach is the practice of screening endoscopy for oesophagogastric varices in patients with cirrhosis and portal hypertension. The Baveno VII Consensus in Portal Hypertension suggests that liver stiffness measurement by transient elastography <15 kPa together with a platelet count of $>150\times10^9$/L rules out clinically significant portal hypertension in compensated advanced chronic liver disease.[25] These patients therefore do not need an endoscopy for assessment of varices. Similarly, non-selective beta-blockers (NSBB) are effective in reducing hepatic venous wedge pressure in patients with clinically significant portal hypertension and only those patients who are not candidates for NSBB may need endoscopic screening.[26] Similarly, it has been suggested that gastric ulcers which look benign macroscopically, have a low-risk score based on location and size and have six negative biopsies may not need endoscopic surveillance as currently recommended by most societies.[27] Coeliac disease can be diagnosed and monitored using serological testing, thereby limiting the need for endoscopic biopsy confirmation to a small number of selected patients.[28] Similarly non-invasive tests such as faecal calprotectin can be used to avoid unnecessary endoscopic procedures[29] with a low likelihood of significant pathology. Finally, up to 80% reduction in colonoscopy-based postpolypectomy surveillance can be achieved by discharging patients to stool testing-based[30] national screening programmes as per the British[31] and European[32] guidelines. Another important consideration is avoiding the need for re-do procedures by having a multidisciplinary team planning in complex cases (eg, large polyps, complex Endoscopic Retrograde Cholangio Pancreatography (ERCP)) to place patients in appropriate specialist lists. Overall, minimising unnecessary procedures can be achieved by innovating alternative options to endoscopy, and by implementing strict evidence-based referral and surveillance algorithms.

While this approach should be regarded as the foundation for a programme of sustainable practice change, it should be recognised that demand for endoscopy tends to increase year-on-year,[11] so other measures must be employed to ensure that those procedures still performed are as efficient as possible.

Practice position statement 1:2

We recommend that sustainable alternatives to conventional diagnostic endoscopy should be considered in all patients where clinically indicated. These might include Cytosponge for Barrett's oesophagus surveillance, CT colonography and colon capsule endoscopy for bowel cancer screening.

Diagnostic (non-therapeutic) upper and lower GI procedures are the bulk of any endoscopy practice, facilitating diagnosis and management of upper and lower GI conditions, excluding cancer in symptomatic patients and as part of a population screening programme (either primary or after stratification by faecal immunochemical test (FIT)).[11] Modalities like colon capsule endoscopy (CCE) and CT colonography (CTC)[33–36] could be more cost-effective and less environmentally impactful but should be evaluated for their cost-effectiveness and environmental impact compared with their equivalent endoscopic procedures. CCE can be performed in primary healthcare settings and may involve retrievable hardware, reducing patient travel as well as negating the carbon footprint of 'traditional' colonoscopy.[34] Incorporation of artificial intelligence in the detection and diagnosis of small polyps during CCE and cloud-based reporting could hasten the adoption of this technology.

There is suggestion in the literature of overutilisation of endoscopy for surveillance of Barrett's oesophagus,[37] while the novel Cytosponge has been shown to be effective in the diagnosis of dysplasia and cellular atypia in a number of studies in the UK (BEST 2, ISRCTN12730505 and BEST 3, ISRCTN68382401 clinical trials). A recent trial demonstrated the effectiveness of using a Cytosponge biomarker panel and clinical risk factors to prioritise endoscopic Barrett's oesophagus surveillance across multiple centres in the UK during COVID-19.[38] In this study, cellular biomarkers of atypia, p53 overexpression were combined with clinical risk factors of age, sex and length of Barrett's segment. Although the carbon footprint of this strategy has not been assessed, it is likely to be less than endoscopy. This strategy can also be implemented in primary healthcare settings and the cytological analysis automated using artificial intelligence.

System-wide service design across regions and integrated care systems may be required for the increased use, where possible, of non-endoscopy procedures such as colon capsules and Cytosponge. These may be provided in Rapid Cancer Diagnostic Centres and community endoscopy hubs, where travel will be less for patients.

Practice position statement 1:3

We recommend that evidence-based methods including simulation and online image libraries should play a role in sustainable endoscopy training.

Endoscopy training faced significant challenges even prior to the COVID-19 pandemic, with 50% of gastroenterologists in the UK, for instance, attaining Certification of Completion of Gastroenterology Training without full colonoscopy sign off.[39–41] If a move to more rational use of endoscopy with green endoscopy is successful, this could represent an additional challenge to training.

The use of simulation represents an evidence-based mitigation strategy to improve training. Demonstrable outcomes include faster overall time to sign-off, higher rates of duodenal (D2) intubation and completion, superior competency scores and aggregate measures of competency.[42–47] This may be of greatest utility in early training, however, with several studies showing a 'saturation effect' after a certain number of simulated procedures, where additional training with simulators does not appear to offer increased benefit.[48–52]

Simulation is likely to be most useful when combined with other evidence-based interventions to improve the overall quality of endoscopy training,[53] including hands-on courses, training for trainers and education on human factors.[54 55 56]

Lesion recognition has been shown to be possible using digital image libraries as well as video recordings of endoscopic procedures and there is good evidence to suggest that this can be achieved in neoplasia detection and characterisation in Barrett's oesophagus (Barrett's Oesophagus Related Neoplasia project).[57] The use of artificial intelligence in detection of neoplastic lesions is likely to further reduce the number of endoscopies needed to achieve competence among trainees.[58]

Practice position statement 1:4

We recommend providing digital patient information and communications to support a sustainable endoscopy unit; however, provision will be needed for patients/service users who require paper copies.

It is universally accepted that structured, comprehensive written information is beneficial for patients undergoing endoscopy.[59] As patients become increasingly engaged in their own healthcare, supported by the growth of information technology, access to patient information in a digital format can be transformative.[60 61]

Many, but not all, are familiar with using digital methods for obtaining information in most aspects of daily life and a recent study,[62] identified that 71% of patients had used quick response codes (QR codes) in the past; the study also demonstrated that this also has the added benefit of environment impact. In endoscopy, personalised digital support at each stage would optimise communication between the patient and healthcare providers.

While there is a literature on digital patient information, the main focus is on retention of information or outcomes rather than environmental consequences, but a number of examples exist.[63] Interactive text message-based systems used in scheduling appointments improve non-attendance rates,[64 65] while patient-facing digital technology can be used in scheduling communications and in pre-assessment.[66]

Disparities in the access to digital information and technologies (the 'digital divide') and its various contributing factors have been identified and must be addressed in any programme of change incorporating these strategies.[67]

Working group 2: sustainable endoscopic procedure-related practices

Practice position statement 2:1

We recommend that, where clinically appropriate, combined procedures ('bidirectional' upper and lower GI endoscopy) should be booked on the same day.

While there is a paucity of evidence for the carbon footprint of bidirectional endoscopy (compared with separate-day procedures), it can be assumed that combining procedures would be associated with the minimisation of patient travel and hospital visits, use of resources such as personal protective equipment (PPE)[9] and clinical consumables (plastic peripherals, tubing, instruments such as biopsy forceps can be shared between procedures)[68]; water and energy; administrative tasks. There is considerable clinical evidence to support the use of bidirectional endoscopy where appropriate, including shorter stays, reduced medical costs such as single-time sedation and fewer missed workdays[69] and that this approach can be employed in differing healthcare funding environments.[70]

Upper GI endoscopy before colonoscopy has been shown to be the optimal sequence since it leads to reduced sedation levels and shorter recovery times.[71 72] It is therefore reasonable to recommend that, where clinically appropriate, bidirectional endoscopy should be preferred as a strategy to minimise the carbon footprint of the two procedures being done on different days. In addition, where appropriate additional tests such as CT staging for cancers and any blood tests should all be performed on the same day and medical treatment prescriptions required postendoscopy also given on the same day.

Practice position statement 2:2

The environmental impact of a pathway employing single-use endoscopes is not yet clear. We recommend that their use should be restricted to select indications and environmental impact taken into account.

The emergence of single-use endoscopes for GI endoscopy is a relatively new phenomenon,[73] while there is more data available for other indications (eg, endotracheal intubation, bronchoscopy and cystoscopy).[74 75] The avoidance, wherever possible, of the use of new ('virgin') plastics is a general central tenetof environmental sustainability.[76] While this appears to be at odds with the introduction of single-use endoscopes, robust life-cycle assessment and estimation of the waste and carbon footprint of the entire endoscopy pathway has yet to be completed. Although single-use disposable endoscopes may incur lower acquisition costs, no reprocessing costs and no risk of cross-contamination, there are major concerns around plastic pollution and increase in net waste raised by early attempts to measure the impact of these technologies compared with existing practice.[77–79]

The clinical argument for the introduction of single-use endoscopes is the elimination of transmissible infections through endoscopes. In GI endoscopy, infectious outbreaks predominantly linked to duodenoscopes have been widely publicised[80–85] and are related to the finding of resistant biofilms or infectious microparticles on endoscopes that have been through an established decontamination process.[86–88] However, these data are incomplete and may vastly overestimate the risk of transmissible infection through either gastroscopes or colonoscopes.[89–91] It is worth noting that, in healthcare environments with strictly regulated and centrally determined decontamination procedures, there have been no such reported outbreaks.[92–94] A recent study[95] concluded that CO_2 emissions associated with single-use scopes is 24–47 times that of reusable scopes, with manufacturing accounting for over 90% of the greenhouse gas emissions. In this specific context, the use of disposable elevator caps might be a more sustainable alternative to disposable complete duodenoscopes[95–98] and is recommended for further evaluation by national bodies.[99] A reduction in transmissible infections after ERCP may therefore be achieved by innovations to endoscope design, optimising decontamination and reprocessing[100] as well as adoption of quality assurance measures.[77] A biofilm is an inevitable byproduct of an endoscope coming in contact with biological fluids in the digestive tract and important for transmission of infections. An essential element of destroying this biofilm relies on a chemical disinfectant being able to destroy a polysaccharide network, both by manual disinfection followed by automated disinfection.[78] The biofilm in the distal attachment of duodneoscopes are resistant to chemical disinfection due to their complex architecture. Gastroscopes and Colonoscopes do not have the complex distal architecture that duodenoscopes do, and hence are easier to clean. Practically no cases of gastroscope or colonoscope related transmission of infection have been reported in the United Kingdom, due to stringent policies for scope disinfection and manual cleaning of the biopsy channel. The distal attachment in duodenoscopes has been considered the most important site for bacterial colonisation and disposable distal attachments are a potential option for minimising transmission. More research needs to be done to compare bacterial colonisation in biofilms in these scopes compared with fully disposable single-use duodenoscopes. It needs to be emphasised that inadequate scope reprocessing (including drying) is the leading cause of biofilm-related scope contamination. More data on the infectious potential of endoscopes (either correctly or inadequately processed) are therefore required to make sense of this claim in the context of single-use instruments.[79]

It is acknowledged that reprocessing of reusable scopes is resource-heavy, using as much as 22–30 gallons of water per cycle, disinfectants, detergents and up to 25 kW electricity per day.[7] Single-use disposable endoscopic supplies generate approximately 2 kg of waste per procedure and although waste from reprocessing would decrease, overall disposable waste was projected to be increased by 40% even after accounting for reprocessing.[101] Single-use endoscopes have an impact on natural resources during production, and are likely to have a greater carbon footprint in manufacturing and transport, generating more waste outside of the procedure itself. A preliminary life cycle analysis using single-use endoscopes, with an assumed infection rate of 0.02%, was estimated to generate 20 times the CO_2 emissions of reusable duodenoscopes with production accounting for 96% of the carbon footprint.[102] These data are in conflict with studies using disposable bronchoscopes and ureteroscopes which did not demonstrate a higher carbon footprint.[103 104]

At present, given the uncertainty, we recommend that single-use duodenoscopes be restricted to highly selective indications where: infectious risk is of heightened concern; safe and effective decontamination represents a significant challenge; the risk of not performing endoscopy is an overriding concern. In all situations, an honest acknowledgement of the environmental impact should be a key consideration for decision-makers.

Practice position statement 2:3

Design of new decontamination units must include sustainability as an explicit criterion for procurement of hardware and consumables.

The resource-heavy process of endoscope reprocessing may be subdivided into precleaning, cleaning, disinfection, rinsing, drying and cleaning of reusable components.[4] Each endoscopy wash machine incurs approximately 24.67 kWh equating to 0.017tonnes of CO_2 equivalent per day[7] and the use of sterile water in decontamination is mandated by manufacturers and guidance from societies.[105] The washers, dryers and storage solutions—either combined or independently—should therefore enable an endoscope decontamination process that is sustainably enhanced by reducing the amount of water required per endoscope cleaned (expressed in litres per cycle); reducing energy consumption overall (expressed in CO_2 equivalent per cycle); reducing plastic usage and waste (expressed in g per cycle).[106]

The chemicals needed in the wash cycle should minimise environmental impact with suggested characteristics of pH neutrality, biodegradability, marine life safety certification. Consideration could also be given to whether these are created and supplied with minimal environmental impact (containers, shipping, plastic waste and recycling programmes including collection of empty containers from site, electric delivery fleet). In addition, consideration of safety of the chemicals used for the personnel involved in decontamination should also be considered. Consumables should be made from materials that are either themselves made from recycled or sustainably sourced materials and/or can be recycled at end-of-use. It is not clear at present whether such products exist, but it is likely that these can be manufactured and increasing demand from users will drive innovation in this field.

Practice position statement 2:4

Water is used in endoscope decontamination, peri-procedural flushes and for immersion colonoscopy. We recommend that an agreed standard operating procedure should exist to ensure rationalisation and minimisation of water use.

Practice position statement 2:5

We recommend that tap water may be used for manual flushes through the biopsy valve during endoscopy, but not through automated flushing systems. The use of filtered water could be an alternative, subject to local agreement and protocols, in all scenarios.

Practice position statement 2:6

We recommend further research into sustainable alternatives to mitigate the environmental impact of sterile water use in the endoscopy unit, while meeting infection control standards.

A significant amount of sterile water packaged in plastic bottles is used in endoscopy.[107] Endoscope manufacturers' guidance specifies the use of sterile water in decontamination and through auxiliary water-jet channels. In addition, sterile bottled water is often used for intraprocedural mucosal washing of colon with pump irrigation, water-assisted colonoscopy, filling syringes and endoscope reprocessing. The use of sterile water incurs energy consumption and environmental impact at several stages including: the industrial production of the water itself; creation of plastic containers and packaging; transport of these containers to sites; discarding the empty containers (bags or bottles) into a non-recyclable waste stream. The use of sterile water during colonoscopy should be subject to departmental review and all staff should be aware of the environmental impact of sterile water use in the endoscopy pathway and adding the use of sterile water in the clinical pathway must be justified.

For instance, there is a wide literature to support water immersion (WI) colonoscopy wherever clinical familiarity allows this to take place—this technique also positively impacts procedural key performance indicators (painless insertion, decreasing sedation requirement, improve bowel cleanliness) as well as patient-centred outcomes (improved tolerance) and overall experience (advantageous for therapeutic applications).[108] The average volume of water used is estimated at 336 mL per gastroscopy (7.05 L for 21 oesophago gastro dudoenoscopy (OGDs)); 241 mL per sigmoidoscopy (5.3 L for 24 sigmoidoscopies) and 782 mL per colonoscopy (17.2 L for 22 colonoscopies).[107] If not all water of the 1000 mL container is used for the procedure itself, the remaining water could be employed in other steps in the use of endoscopes, for example, 'bed-side' cleaning.

In addition, reusable bottles and water from potable water filtration systems installed on taps could be considered.[109] However, a number of issues need to be taken into account. The use of tap water has been brought into focus with the specific aim of reducing environmental impact.[109–111] There is a categorical differentiation between tap water, water of drinking quality (potable) and sterile water. The use of sterile water is mandated by current BSG, European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology and Endoscopy Nurses and Associates guidance,[94 106] with derogation for the specific use-case of manual flushes through the working channel of any endoscope, where tap water can be used. Tap water cannot be used in any other scenarios. In a recent update, the Healthcare Infection Society Working Party[105] states that 'water of at least the same quality as "final rinse water" for endoscopes can be used instead of sterile water in automated flushing systems and sterile water bottles'. The quality of the water must be tested and controlled as per guidance for final rinse water.

While the use of sterile water from industrial production described above has not been subject to lifecycle analysis, it is likely that any site-based system enabling the production of 'sterile' water would be favourable, negating the industrial production, packaging, transport and waste steps. Examples would include local reverse osmosis, ultrafiltration or autoclave-sterilisation systems. If local infection control and water quality monitoring procedures are in place, industrially produced and packaged sterile water need not be used in these 'in-room' steps. To accommodate this, a number of factors would need to be included in an agreed plan. These would include (but not be limited to): decontamination and reuse procedures for endoscope water bottles (for air/water channels and irrigation through the auxiliary channels of newer endoscopes); water filters, if used, must be locally evaluated following infection control policies and procured within guidance; a replacement and monitoring programme for all consumables must be established.

Practice position statement 2:7

We recommend that endoscopy departments should consider local protocols to minimise the use of histopathology in appropriate clinical pathways.

The carbon footprint of routine histopathology from GI biopsies has been determined and is not subject to 'economies of scale'. It is estimated that the processing of every three histology pots is equivalent to the carbon emissions of driving 2 miles in an average car[112] (taking into account the pot itself, but not biopsy forceps or instruments used to obtain the sample).

The use of routine or 'confirmatory' biopsies should be discouraged, and consideration given to whether the result of those biopsies will change patient management. In many cases, other tests may be used (and often results are available prior to superfluous biopsies being taken): stool antigen testing for *Helicobacter pylori*, serology for coeliac autoantibodies and digital photo documentation of ileal intubation as well as macroscopic normality.[113] If non-invasive testing is negative, there may be clinically appropriate scenarios in which biopsies are still necessary, but routine biopsies of normal appearances must be avoided if they do not alter management. It has been estimated that upper GI endoscopy itself influences the clinical management of patients in approximately only one-sixth of cases[114] and biopsies are taken in most (83%) cases. Optical Biopsy instead of histopathology has been suggested for diminutive polyps by the ESGE, in certain situations, and with regular audit and training and with regular audit and training, by the ESGE.[115 116] The 'resect and discard' strategy has been discussed in some guidelines[31] and considered to be feasible in a meta-analysis,[117] but potential barriers such as the fear of missing high-grade dysplasia and remuneration considerations prevent wide adoption.[118] The rationalisation of endoscopy itself must go hand-in-hand with biopsy protocols and departments should agree protocols to minimise unnecessary use of histopathology. The advent of artificial intelligence in endoscopic diagnosis and characterisation may also help in reducing the need for histopathology in several settings,[119] but further work is required before the impact of such a pathway could be confirmed.

Practice position statement 2:8

We recommend that use of endoscopy accessories should be carefully considered and planned preprocedure. This is an important endoscopic non-technical skill and could be part of training alongside endoscopic technique.

Endoscopic procedures use multiple accessories, the majority of which are currently non-recyclable and hence incinerated at high temperatures. These include biopsy forceps, biopsy containers, cold and hot snare catheters, snare diathermy pads and others. The risk of cross-contamination and patient safety concerns have led to the almost ubiquitous use of single-use accessories,[120–122] but such disposable equipment is likely to increase net waste.[101] To mitigate the environmental impact of disposable accessories, training endoscopists and staff in preventing excess and inadvertent use of accessories by appropriate planning preprocedure is recommended.[123] Innovation in equipment design, to facilitate waste minimisation, is required in this field.

Practice position statement 2:9

We recommend that the significant adverse environmental effects of nitrous oxide must be considered against its clinical efficacy in GI endoscopy. Staff and patients should be provided information on the environmental impact of nitrous oxide.

A wide range of methods have been studied to alleviate pain and discomfort during colonoscopy, including: different types of sedation; antispasmodics; sublingual hyoscyamine spray; patient-controlled analgesia; nitrous oxide (NOX); variable stiffness colonoscopes, WI or exchange; electro-acupuncture; music; positional manoeuvring. Entonox (a 50:50 mixture of NOX and oxygen) has analgesic and sedative properties and is a useful analgesic agent in many clinical scenarios with a good safety profile, rapid onset of action and washout.[124] In GI endoscopy, a Cochrane meta-analysis[125] demonstrated efficacy, but in relatively small numbers of patients with some studies returning equivocal results.

NOX is an important GHG with approximately 300 times the greenhouse effect of carbon dioxide. It is estimated to persist in the atmosphere, once released, for over a century and also destroys the ozone layer. Most NOX emissions are not associated with healthcare, but given the above characteristics, it accounts for nearly half of the medical gas ‘footprint’ from hospitals.[126 127] Furthermore, it is a major cause of ongoing ozone depletion.[128] Introduction of NOX capture and catalytic destruction devices in Swedish hospitals and maternity units resulted in a 50% reduction in GHG emissions in maternity services,[129] but this is an additional cost pressure (as well as manufacturing demand for new equipment). Consideration should be given to substituting for other low-impact methods. Judicious use to reduce waste in delivery systems and installation of catalytic destruction systems to reduce environmental escape could have a considerable impact on reducing GHG emissions. The continued use of NOX must be subject to the hospital’s overall medical gases strategy, taking into account the environmental impact of its production, transport and delivery, use and atmospheric escape. Furthermore, information about the environmental impact of NOX should be available for staff and patients to make fully informed choice in relation to its use (online supplemental appendix 1). Propofol infusions are associated with lower GHG emissions than NOX but they create more medical waste in the form of syringes, syringe tubing, antireflux valves, additional intravenous catheters, delivery pumps.[130]

Working group 3: sustainability in endoscopy environment

Practice position statement 3:1

We recommend endoscopy units adopt sustainable reporting practices such as electronic documentation and reporting and report dissemination.

A significant proportion (30%) of all hospital waste is paper.[131] The recognition of this has led to the NHS goal to reduce paper use by 50% by 2022,[132] while ensuring supplies are from recycled stock. Printer supply chains, volatile organic compounds released from solvents and paper all contribute to GHG emissions.[133] An institution in the USA created a model to investigate the environmental effect of electronic health records and found a positive net effect on the environment, eliminating 1000 tonnes of paper records.[134] Incorporating a ‘paperless endoscopy unit’ principle using comprehensive electronic records for all administrative, nursing and endoscopic documentation could be achieved in most settings.[135] Such a system will have the added benefit of efficiency, ensuring quality control and reducing labelling errors. If wider hospital systems do not support electronic documentation and reporting, practical measures such as reducing the number of print copies, and encouraging its recycling, printing in black and white and using recycled paper should be considered.[136]

Practice position statement 3:2

We recommend reduction in personal protective equipment (PPE) use where possible and maximising availability of reusable PPE in endoscopy.

The COVID-19 pandemic has resulted in high volume use of single-use PPE during endoscopy including face masks, gowns, aprons and gloves.[137] A recent study conducted in the UK over a 6-month period, during the pandemic, indicated generation of 591 tonnes of CO_2 equivalent per day with the biggest impact from gloves, aprons, face shields and masks.[138] The same study found that use of reusable rather than disposable gowns would reduce carbon footprint by two-thirds. While it is important that infection control measures are followed, and risk to staff is minimised, the phasing out of unnecessary PPE and single-use items is advisable and a policy to rationalise the use of gloves and single-use masks would be beneficial.[139 140] Reusable gowns are already available and used in healthcare settings such as operating theatres and endoscopy units.[141] Furthermore, the environmental impact of gloves can be reduced by using powder coating gloves rather than chlorination to reduce stickiness.[142] In addition, cohorting of COVID-19-positive patients in dedicated endoscopy lists may also minimise PPE-related waste.[4] Where single-use PPE cannot be reduced, several studies have suggested recycling as a way of tackling the mass amount of single-use plastic waste generated. A recent study suggests that face masks and gloves could be transformed into fuel energy via pyrolysis, a high temperature decomposition process.[143] Similarly, thermal technologies can also compress the PPE in rectangular plastic blocks to produce new plastic products thereby reducing the waste volumes and associated transport.[144]

Practice position statement 3:3

We recommend flexible working patterns for appropriate team members should be actively encouraged, to enable remote working where possible.

GHG emissions associated with staff commuting contribute 4% of the NHS carbon footprint.[145] Travel emissions to and from the endoscopy unit are affected by transport mode and vehicle occupancy with 85% of trips to and from work being single occupancy. While types of travel cannot be dictated and are subject to distance and a number of other factors, walking, bicycles and efficient public transportation is one of the actions endoscopy staff can take to reduce GHG emissions associated with staff commuting.[146]

In addition, the COVID-19 pandemic has shown that many staff are able to carry out their roles remotely and do not always have to be at the hospital, providing they have access to suitable technology to work remotely and in some cases from home. Working from home reduces both air pollution and GHG emissions from travel as well as having local health co-benefits.[147] Home working also promotes flexible working,[148] and in the report 'delivering a "net-zero"' NHS,[12] flexible working patterns have been recommended, particularly to support alternative, more sustainable travel. Flexible working for staff has also been shown to improve patient care, staff morale and work-life balance.[149] These may include administration staff working from home, endoscopists doing administrative work from home and phone pre-assessments for endoscopic procedures and reporting of capsule endoscopy, etc being done remotely.

Practice position statement 3:4

We recommend low flow devices on water taps. If hands are not visibly soiled, then use of other appropriate hand disinfectants should be considered.

The most common water saving recommendations focuses around installing low flow devices on taps and toilets.[150] Sensor-activated taps have been shown to reduce water usage by ensuring water is not left running continuously.

Numerous studies also highlight opportunities for reduction in water use during/for surgical scrubbing. While in endoscopy, full hand disinfection is not required, these studies are still relevant for our practice. Switching from an 'elbow-on' tap operating system to a leg-operated tap was found to save 5.7 L of water per scrub.[151] Method of hand hygiene should also be considered, a study on surgical scrubbing in the UK found using alcohol-based hand gel could save approximately 930 000 L of water per year for an average UK hospital.[152] Recently, Duane *et al*[153] conducted a hand hygiene life cycle analysis and concluded that alcohol-based hand gel was more environmentally sustainable than handwashing with soap. However, it should be noted that this study compared the hand hygiene methods at population level use rather than within a hospital setting in which the alcohol gel might not be suitable for clinical use. Alcohol gel can only replace water, however, when hands are not visibly soiled or in contact with potential spore-forming pathogens such as *Clostridium difficile*.

Practice position statement 3:5

We recommend that energy to power endoscopy units should come from renewable sources, wherever possible.

Endoscopy units are energy-intensive environments, the environmental impact of which depends on the structural configuration of units, demand and the energy source. The energy hierarchy should be followed wherever possible, reducing demand/consumption, improving energy efficiency followed by using renewable energy sources.[154] Units should seek opportunities to move away from their reliance on fossil fuels and generators and focus on decarbonising energy sources where possible. However, this may be challenging if units are not standalone, which is commonplace for endoscopy units, and would therefore require whole hospitals to decarbonise their energy sources.[155] An example of this is the Antrim Area Hospital in Northern Ireland, which has a wind turbine and solar panels installed which provide enough electricity for the hospital at night and two-thirds during the day.[156]

Practice position statement 3:6

We recommend energy-efficient lighting and motion sensors for endoscopy units, where appropriate. In addition, aside from critical equipment such as drying cabinets, we recommend all equipment, including computers and machines, should be turned off when not in use.

A systematic review of GHG emissions in theatres identified electricity usage as a carbon hotspot, which can be extrapolated to endoscopy units on a smaller scale.[157] Endoscopy units are consumers of electricity for lighting, computers and endoscopy equipment.[158] Sources of electricity waste include the usage of energy inefficient bulbs (eg, incandescent and halide) and the lack of attention to whether lights and devices such as computers are switched off when not in use and at the end of the working day.[4]

Many studies advocate the reduction in 'out-of-hour' energy usage[18] through 'power down' initiatives turning off lights and equipment when not in use.[159 160] Asfaw *et al* also recommend a 'power down' checklist driven by frontline staff.[161] This is not applicable to critical equipment such as drying cabinets which often need to be left on for infection control purposes. Other innovative drying and prolonged storage solutions which replace the need for drying cabinets are being developed but these are not in widespread use.

Light-emitting diodes (LEDs) are more efficient lighting systems than traditional incandescent bulbs,[162] having a longer lifespan and reducing energy use by 65%.[163 164] Installation of LEDs with occupancy sensors in a unit resulted in GHG emissions cut by two-thirds and a 62% cut in lighting costs.[163]

Practice position statement 3:7

We recommend the waste hierarchy must be followed and triage of contaminated, non-contaminated and recyclable waste should be a priority for all endoscopy units.

Endoscopy is the third largest waste generating department in a hospital.[3] Gayam *et al* estimated an endoscopy unit performing 40 endoscopies per day produces 13 500 tonnes of plastic waste per year.[8] These studies highlight the need for endoscopy to urgently reduce its GHG emissions associated with waste disposal.[4] Units must first follow the 'reduce' and 'reuse' principles of the waste hierarchy. Where there is still waste being generated, recycling must be made a priority. Multiple studies from endoscopy and intensive care units show that 20%–30% of waste is potentially recyclable.[7 165 166] Recycled hospital waste (21–65 kg CO_2 equivalent) has a carbon footprint of up to 50 times less than high temperature incinerated waste (1074 kg CO_2 equivalent).[167] By improving recycling rates, there is opportunity to make significant environmental and financial gains.

Practical measures to promote recycling include correct segregation of waste, more accessibility to recycling bins and targeting

Figure 1 Waste segregation in endoscopy. NG, naso gastric; PEG, percutaneous endoscopic gastrostomy.

ergonomic layouts of recycling bins.[4] Endoscopy units must therefore ensure they have the correct waste set up ensuring that recycling bins are placed in each and every endoscopy units/treatment room. Easily displayed signage on common endoscopy items that can be recycled should be placed above bins.[168] Endoscopy unit materials which are regulated waste material meant for 'red bag containers' include containers with blood or blood products, items saturated with blood, soiled materials from patients on contact precautions, suction canisters, sharp bin materials. Disposable gloves and gowns used for endoscopic procedures should not be placed into these containers. Nearly every endoscopic tool from biopsy forceps to endoscopic suturing devices are manufactured in bulky plastic wrap and pending development of more biodegradable products by the industry, diverting non-soiled plastic waste to recycling within the endoscopy unit will prevent a large amount of plastic being sent to landfill. In a recent quality improvement project which determined the volume of recyclable waste generated within endoscopy suggested that the use of a green bin reduced GHG emissions and financial cost.[169] Incorporating proper waste management into the hospital quality measures is an important step in improving performance. A proposed waste segregation scheme is given in figure 1.

Practice position statement 3:8

We recommend education of all endoscopy staff in waste management.

Alongside better waste infrastructure, there must be staff education to improve waste management. A survey of healthcare staff across four US hospitals found that 57% of staff reported being unclear on what items are recyclable in an operating room.[170] Similarly, Mosquera *et al* found that educational intervention significantly reduced infectious healthcare waste volume.[171] Waste education could be achieved via an e-learning module or video, mandatory training, staff teaching sessions and reinforced during daily safety briefs on endoscopy units. In addition, dedicated green endoscopy champions in endoscopy units to provide information such as waste allocation and other sustainable principles are recommended.[172]

Practice position statement 3:9

We recommend heating, ventilation and air conditioning setbacks to minimise air exchanges when endoscopy rooms are not in use.

High ventilation requirements make hospitals energy intensive. Heating, ventilation and air conditioning (HVAC) is typically responsible for the greatest proportion of end-use energy in hospitals[173] and has been shown to be responsible for 90%–99% of theatre energy use.[174] While there are no data on HVAC energy requirements for an endoscopy room, they are required to be negatively pressurised resulting in significant energy usage.[175] While there are specific ventilation requirements, hospital ventilation is often left running during non-occupation (eg, overnight). Several studies have looked at air cleanliness in unoccupied operating rooms. There is evidence of no difference in microbial levels from operating rooms where the ventilators are setback to reduce air flow in unoccupied operating rooms overnight compared with continuous ventilator usage.[176 177] Existing literature reviewed also shows that ventilation setbacks maintain

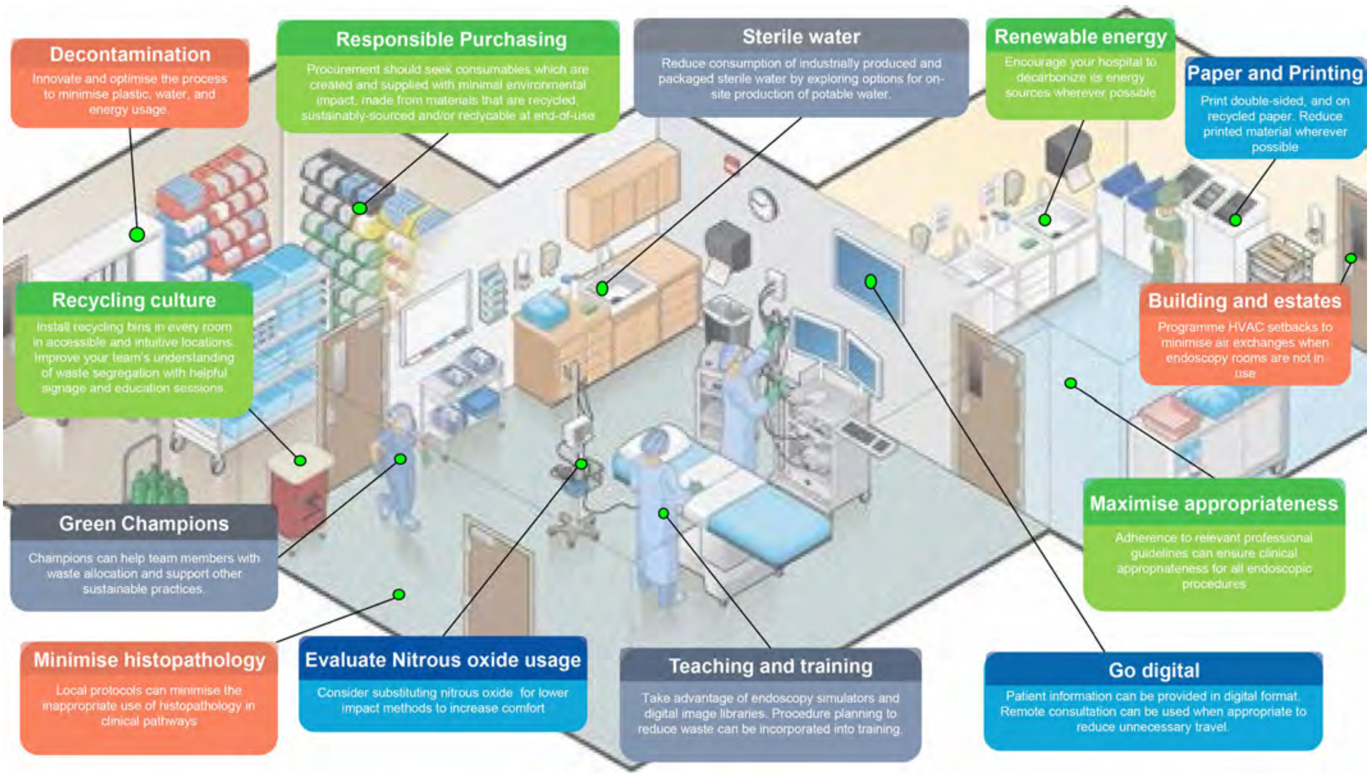

Figure 2 Practical tips for a green endoscopy unit. HVAC, heating, ventilation and air conditioning.

the air pressure needs required for operating rooms which would also apply to endoscopy rooms.[178 179] A degree rise or reduction in temperature in winter/summer can reduce energy costs by 5%.[173]

Working group 4: sustainability considerations postendoscopic procedures

Practice position statement 4:1

Patients should be encouraged to bring their own reusable drinks bottle or cup for the purpose of refreshments.

Food and catering are responsible for approximately 6% of total emissions within the NHS.[180] Approximately 2 million endoscopic procedures are performed in the UK per year,[4] and most of these patients will be provided with a postendoscopy drink, generally served in a plastic or polystyrene cup, and a snack of biscuits or toast.

Single-use cups have similar environmental impacts regardless of the material from which they are made.[181] If single-use cups are to be used, then paper has the lowest associated carbon footprint, and recycling halves the environmental impact by a further 40% to approximately 10 g CO_2 equivalent per cup. However, if 1 million paper cups were used by endoscopy units in the UK (a conservative estimate), this would still contribute 10 tonnes of CO_2 equivalent in emissions.

While some analyses suggest that reusable cups are associated with a threefold reduction in GHG emissions compared with disposable,[182] the comparative environmental impact benefit of institutional adoption of reusable cups over single use is dependent on a number of site-specific variables, including: energy mix, waste management strategy end-of-life technology used, recycling infrastructure and the efficiency of washing machines.[182] However, if patients already own a reusable drinks bottle or cup, they could be encouraged to bring their own. This could be communicated in the patient information leaflet prior to the appointment. Some hospitals in the UK have already used this approach; it has not led to any complaints and, anecdotally, has allowed the endoscopy unit to run more efficiently.

Practice position statement 4:2

Patient information leaflets and discharge instructions should be offered to patients in a digital format. For those patients requesting information in paper form, this should be printed on recycled paper with double-sided printing.

The JAG advises that all patients undergoing endoscopic procedures are given written information explaining aftercare and follow-up arrangements in addition to a copy of the endoscopy report. Many will also be provided with relevant written information if they are given a new diagnosis. Patients usually leave the endoscopy unit with two pieces of A4 paper in addition to their report. Although paper consumption alone accounts for a relatively small proportion of the overall environmental impact of the healthcare system,[183] a unit carrying out 12 000 procedures per year would use 24 000 sheets of paper for this purpose alone, which equates to 109 kg CO_2 equivalent.[183] Digitising paper information leaflets would reduce endoscopy's environmental impact, reduce the need for storage space and may also be preferred by patients.[184] The operational efficiency advantages of digitisation in this context have not been formally evaluated, nor is it yet clear which mode of digital information delivery has the highest level of acceptability with patients.

One option would be to offer patients a QR code linking to an electronic version of the relevant information, which can be stored on their mobile phone or tablet device for reference at a later date.[184] The discharging nurse would have a laminated sheet with all relevant QR codes, including those in different languages. For those who decline electronic versions consideration should

Research Themes

Pre procedure	
	Large multicentre prospective trials to further evaluate the performance of non-endoscopic technologies
	Determine the environmental impacts of non-endoscopic diagnostic pathways (colon capsule endoscopy, Cytosponge, CT colonography)
Procedural	
	Comprehensive environmental impact assessment of an endoscopic procedure. Identify the 'hotspot' areas within the process which contribute most to this impact
	Engineer and design of effective accessories, consumables and packaging to minimise waste and maximise recyclability and biodegradability
	Comparative life cycle assessment of single use versus reusable endoscopes
	Determine the net effect of artificial intelligence systems on histopathology demand
Postprocedure	
	Determine the environmental impacts of the endoscope decontamination processes
	Innovate improvements to the endoscope decontamination process which reduce per-cycle water, energy and plastic use.
	Develop effective wash cycle chemicals with optimal pH neutrality, biodegradability, and which meet marine life safety certification requirements
	Develop solutions to drying and prolonged storage of endoscopes which replace the need for energy-intensive drying cabinets
	Determine the incidence of clinically significant infection arising from contaminated endoscopes in the context of gastroscopy, duodenoscopy and colonoscopy.
	Determine the effect of endoscope modification (eg, disposable elevator caps) on endoscope contamination rate
General	
	Evaluate the efficacy and environmental impact of strategies for site-based production of 'sterile' water for example local reverse-osmosis, ultrafiltration or autoclave-sterilisation systems.
	Determine the optimal level and materials for an effective PPE policy to minimise overuse and environmental impacts
	Stakeholder review (clinicians, patients, policy makers) to understand barriers to change and how to best integrate environmental impact data into decision making
	Evaluation of educational interventions to improve environmentally sustainable practices
	Define environmental key performance measures for a sustainable endoscopy unit

Figure 3 Research themes. PPE, personal protective equipment.

be given to using recycled paper, double-sided printing and storing as few copies of each leaflet as possible, especially if not used on a frequent basis.[185 186]

Practice position statement 4:3

Remote consultation should be seen as the default means of providing postendoscopy follow-up. Patient selection and engagement are critical to ensure success and avoid widening health inequalities.

Many countries have seen a shift towards remote consultation (accelerated by the COVID-19 pandemic) and evidence-based guidance is now available for telephone and video consultations.[187] Remote consultation can reduce waiting times when compared with face-to-face appointments, and they have the potential to significantly decrease GHG emissions across the healthcare economy, primarily through reduced travel-associated emissions. The environmental impact varies between urban and rural settings as well as general and more specialised care.[188] Most studies have focused on the environmental impact of travel with few studies using life cycle assessment methodology.

The success of remote consultation as a means of providing high-quality healthcare has been well documented in recent studies,[189] but is highly context specific; endoscopic-specific literature is lacking. One study examined its use in GI practice and found high levels of satisfaction for both patients and providers with video consultations.[190] Another study demonstrated that patients seen for follow-up care, medication-related issues and pre procedural appointments were particularly satisfied with their virtual visits.[191]

However, telemedicine may exacerbate health inequalities by 'widening the digital divide': one study showed that 0% of patients who indicated their health as 'poor' reported using telemedicine in the past year.[192] The most common barriers from the patient's perspective are age, level of education, computer literacy, bandwidth and unawareness of services, whereas providers struggled with cost, reimbursement, legal liability, privacy confidentiality, security of data, effectiveness, old equipment and efficiency.

Practice position statement 4:4

Adoption of less-invasive tools may represent an opportunity to reduce the environmental impact associated with endoscopic surveillance, but their use in this context is currently limited to trials and pilot settings.

Endoscopic surveillance carries a significant burden for both patients and healthcare systems. Given the resource intensity that accompanies hospital-based procedures, appropriately reducing the number of unnecessary endoscopic surveillance procedures performed is also likely to be an effective route to mitigation of endoscopy's environmental impact. The less-invasive alternatives to endoscopy proposed for use in surveillance include FIT, CCE and Cytosponge.

Given the very low rate of progression to neoplasia for non-dysplastic Barrett's oesophagus (0.3%/year), there is a need to better identify those patients who benefit from endoscopic surveillance. Cytosponge could play a role in this risk stratification process,[38] and while its use in this context is not yet in national guidelines, its use is being rolled out in Scotland.[193] Evidence from further large-scale, longitudinal follow-up may support wider uptake for this indication.

In the UK, approximately 15% of the half a million colonoscopies performed each year are performed for polyp surveillance.[31] While FIT is deemed to have validity in guiding referral for colonoscopy in bowel cancer screening and in patients with low-risk symptoms of colorectal cancer (CRC), current British,[31] European[32] and American[194] guidelines do not deem there to be sufficient evidence to safely use FIT for polyp surveillance, with concerns that such a strategy would carry an unacceptable CRC miss rate. British[31] and European[32] guidelines also conclude that there is insufficient evidence at present to support the use of CCE in this context.

It is important to emphasise that there are no published data on the environmental impact of many of these less-invasive technologies, and so comparative ecological benefit cannot always be entirely assumed until a life cycle assessment is formally undertaken.

DISCUSSION

We present the first set of societal consensus statements on sustainable practice in GI endoscopy. The case for mitigating the environmental impact of healthcare in general, and GI endoscopy in particular, is clear. High volumes of procedures, multiple single-use items with non-renewable waste streams, water use in procedural flushes as well as decontamination will all contribute to this effect. 'Outside the endoscopy room' contributors including patient and staff travel, education and training and conference travel must also be taken into consideration as our specialty is responsible for these factors too. In this consensus, we provide a blueprint for practical actions promoting sustainability through the entire endoscopy journey of patients from preprocedural, procedural and postprocedural stages (figure 2).

The case for change, therefore, is urgent and compelling, receiving widespread support internationally. We sought to distil current knowledge from environmental science and practice, from other fields or disciplines, to apply to our own practice. While many statements, therefore, are unsupported by direct evidence, there are sufficient data from related scenarios that support a logical deduction towards more environmental practices.

There is a pressing need for high-quality research to better inform individual choices and practice change, but individual intervention (at the departmental level) can achieve considerable impact in the meantime. Estimates of the carbon footprint of endoscopy should be sufficient to describe the scale of the problem and stimulate change.

The tension between some environmentally sustainable practices and infection control imperatives (recycling in particular) should be acknowledged. We must not jeopardise patient safety in a push to 'net zero', but neither should this be a barrier to change wherever possible. Some protocols, for instance, water use, can be subdivided to allow sustainable alternatives to emerge. The principles surrounding infection control practices (often established well before sustainable practice was conceptualised) should therefore be scrutinised and reviewed at local and national levels.

Engagement with industry is vital in our move to an optimally sustainable practice. Healthcare systems have significant financial influence to nudge suppliers and manufacturers to encourage innovation and change.

We hope that these consensus statements will provide meaningful guidance to individuals and units to take immediate steps to becoming more sustainable, as well as stimulating further research and innovation. Multimodal change is needed as soon as possible to meet perhaps the greatest clinical challenge of our lifetime.

Recommendations for future research

The literature review and Delphi consensus process for the document identified a number of key gaps in evidence relating to sustainability in endoscopy. Overall, the research is limited and there is an urgent need for large-scale studies addressing the key knowledge gaps. Gastroenterologists and endoscopists are not fully trained to understand sustainability research and so need to work closely with environmentalists, engineers and economists to design these studies in a scientific manner. This will need collaborative research including academic groups, universities, professional societies and the industry on a scale and speed similar to the research on the COVID-19 pandemic. The key research areas and the relevant questions to be addressed are highlighted in figure 3.

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Patient information Leaflet

Entonox using in colonoscopy

What is Entonox?

It is an option offered for easing pain also called `gas and air`

It is also commonly used for pain relief during labour

It`s a mix of nitrous oxide (laughing gas) and oxygen

You breathe it in through a mouthpiece

The amount used is controlled by the patient and depending on the discomfort

What are the advantages of Entonox use during colonoscopy?

Entonox is offered as an alternative to sedation and pain killers

It is particularly offered if there is no aftercare available to enable use of sedation

While the dose of sedatives used is optimised for safety, Entonox is considered safer than sedation

Recovery time post procedure may be shorter with use of Entonox

You will be able to drive or return home after your colonoscopy without an escort if using Entonox

When is Entonox not offered?

It must be avoided if you have a pneumothorax

It is avoided in those with bowel obstruction

It should not be given if you have recent head injury

It should be avoided following a recent dive

It is avoided in patients with COPD or other long-term lung conditions

It is avoided in patients who are on methotrexate

It is avoided in patients who has had recent middle ear or retinal surgery

Any side effects to using Entonox?

As the amount used is controlled by yourselves and often reactive the amount of discomfort

It is important to take in slow deep breaths while using Entonox and if you are very anxious you may find this difficult

Most side effects are minimal and wear off quickly and included nausea or light headedness

What are the alternatives to using Entonox?

Common alternative to Entonox is the use of sedatives (midazolam) and pain killers (fentanyl)

You will need someone to take you home after the procedure and be accompanied for 24 hours.

You should not drive or work for 24 hours after receiving sedation

The dose used for sedation is determined by endoscopists ensuring safety

Does Entonox have impact on environment?

Entonox is a greenhouse gas

The global warming potential of Entonox is 300 times that of carbon dioxide

When used in healthcare, up to 60% of Entonox escapes into the atmosphere

It remains in the atmosphere for 110 years once released

Endoscopy departments are looking at ways to minimise overall Entonox use and reduce environmental leakage

You may wish to avoid using Entonox to minimise harm to the environment and if so please inform your nurse or endoscopist.