Green Endoscopy: Counting the Carbon Cost of Our Practice

"Humans were always far better at inventing tools than using them wisely."
–Yuval Noah Harari

The desire to peer into the recesses of our bodies cannot be dismissed as a modern preoccupation. The arc of innovation leading to modern endoscopy can be traced back to the turn of the 19th century and instruments designed to explore our bodily cavities used by early physicians 3,000 years ago.[1] There is now an additional clinical imperative for early diagnosis and treatment.

For innovators of the early endoscope, such as Bozzini with his Lichtleiter, the route into the lightless depths of the bowel was lit only by candlelight guided through a speculum with a silver mirror. Today's endoscopic technology, which permits us to examine the busy walls of the gut at a cellular level or traverse the lumen with ultrasonography, would surely be considered a wonder by our ancestors. Human ingenuity, building on the shoulders of each generation's efforts, has produced diagnostic and therapeutic options that would have been a pipe dream to physicians practicing just a few generations ago.

However, when seen from a planetary perspective, judging the history of this technological progress solely by the height of our diagnostic and therapeutic leaps paints only part of the picture. These achievements could also be understood to represent the apex of a pyramid, the body of which constitutes a vast and often invisible infrastructure. As we stretched our technological capabilities higher, the body of this infrastructure swelled, and the environmental footprint left by its base deepened. Here, we turn our attention to that footprint and explore ways that we as a community may lessen the carbon cost of our endoscopic practice.

Endoscopy's Carbon Footprint

Health care systems are making huge commitments to decarbonization: the United Kingdom's National Health Service has committed to a net-zero carbon footprint for directly controlled emissions by 2040 and net zero for those within its supply chain (indirect) by 2045. Other health care systems made similar pledges at the COP26 (The United Nations Climate Change Conference 2021) summit.

Gastrointestinal endoscopy is a resource-intensive specialty, and there are many reasons why it represents a significant contributor to a hospital's footprint: high throughput caseloads, repeated travel for patients and relatives, multiple nonrenewable waste streams, single-use consumables, and resource-heavy decontamination processes. In the effort to decarbonize health care, endoscopy therefore represents a high-yield mitigation opportunity. To its advantage, several structural features of an endoscopy department—an economically discrete, defined physical area, with its own facilities directorate responsible for its own supply chain—may afford it greater autonomy and control over its resource use than other areas of the hospital.[2]

Formal quantification of a carbon footprint is usually obtained using life cycle assessment, a methodology used to assess a product's environmental impact throughout its entire life cycle, from the extraction of raw materials to manufacturing, distribution, use, and disposal. Although this comprehensive assessment has not yet been applied to endoscopy, more approximate calculations have been published that at least convey the scale of our environmental impact: in the United States alone, this amounts to approximately 86,000 tonnes of CO_2 equivalent of greenhouse gas emissions, the equivalent of 213,000,000 miles driven in a passenger car.[3] Each endoscopy bed-day is thought to create approximately 3 kg in waste, and the specialty is responsible for 13,500 tons of plastic waste in the United States per year, making it the third-highest generator of waste in the hospital.[4,5] Importantly, many of these are underestimates because they do not fully account for the significant emissions resulting from activities within the supply chain (termed *scope 3 emissions*).

Alternatives to Endoscopic Procedures

Given the resource intensity that accompanies hospital-based procedures, appropriately reducing the number of unnecessary endoscopic procedures performed (ie, triage) is likely to be the single most effective route to mitigation of our impact. It is axiomatic that "the greatest waste is a procedure that did not need to be performed," but the decarbonization effort cannot end with this step because demand for endoscopy rises year on year.

Of increasing interest are home-based, noninvasive alternatives to endoscopy and diagnostic tools that increase the yield of invasive investigations. The use of fecal calprotectin is well established in symptomatic patients to help distinguish between inflammatory bowel disease and functional disorders that do not require colonoscopy. Fecal immunochemical test, as an adjunct to clinical acumen, can help triage patients, assessing their risk of harboring significant bowel pathology.

Colon capsule endoscopy (CCE) appears to reduce the proportion of symptomatic patients requiring colonoscopy (reported to be at least 37%).[6] This proportion is likely to be even greater if diminutive polyps are not followed up, because these accounted for 38% of those deemed to require further colonoscopy in this study. CCE might also be considered in the context of colorectal cancer screening,[7] and further trials of CCE in this context are underway.

Given the low rate of progression to cancer in those with nondysplastic Barrett's esophagus, the need to better prioritize surveillance is well recognized. Cytosponge could play a role in risk stratifying these patients and better identifying which need endoscopic surveillance.[8]

It is important to emphasize that there are no published data on the environmental impact of many of these noninvasive technologies, and so comparative ecological benefit cannot be entirely assumed until this is formally undertaken.

Administration of an Endoscopy Service

Operational inefficiency within complex health care systems is well recognized. However, much of the work required to avoid duplication of activity and wasted resources does not require a wholesale change or new technology but, rather, the robust, careful administration of an endoscopy department.[2]

Oversurveillance and inappropriate referrals for endoscopy are a challenge for most departments. International guidelines list accepted indications for diagnostic and surveillance endoscopy.[9] The quality of triage is likely to be improved when decision makers are provided with protected time for the task and all clinical information required to assess the referral is provided in a format that prioritizes the pertinent clinical information. Resources invested to ensure that this process is robust would be more than compensated for by the reduction in unnecessary endoscopic activity.

Patient and staff travel accounts for approximately 10% of the carbon footprint of the United Kingdom's National Health Service.[10] Simple measures to address this might include ensuring that patients requiring both upper and lower gastrointestinal tract investigation are scheduled for the same day, telemedicine for consulting and preassessment (which has been accelerated by the COVID-19 pandemic), and virtual or digital follow-up. It would be assumed that remote consulting is environmentally preferable, but its success is highly context specific, and patient selection and engagement are critical.

Paper use can be reduced by the digitalization of endoscopy reports, patient information, and appointment letters and reminders whenever possible or the use of paper from recycled sources when not. Digital data storage (especially video) also incurs a carbon footprint, and this needs to be balanced with the need to facilitate governance and direct health care delivery. The provision of patient refreshments should avoid single-use plastic wherever possible.

The structural design of a department can minimize operational resource use. Endoscopy units are energy intensive by virtue of the electricity use required in climatization, lighting, and computer and processor use. Emissions from electricity use could be mitigated through the installation of low-energy LED lighting, motion sensor systems operating lighting and taps, and timer-controlled electronic thermostats.[3]

Procedural Considerations

Although isolated adjustments to our procedural practice are unlikely to yield the greatest reduction in the environmental impact of our specialty, there are opportunities to lessen our impact without compromising the quality of care. Nitrous oxide is known to carry 300 times the global warming potential of carbon dioxide. From an environmental impact perspective, alternative options to improve the tolerability of colonoscopy should be encouraged. Significant quantities of sterile bottled water are used for intraprocedural pump irrigation, water-assisted colonoscopy and mucosal washing, filling syringes, and endoscope reprocessing, with the associated plastic bottles, adaptor caps, and sterilization. For our intraprocedural water use, we could instead use reusable bottles and water from potable water filtration systems installed on taps.[11]

Processing gastrointestinal biopsies represents added energy expenditure, generates hazardous waste, and incurs a significant carbon footprint. Processing 3 biopsy pots is equivalent to driving 2 miles in a car.[12] Demand can be reduced without altering the management of most patients by ensuring that appropriate biopsies are undertaken or avoided altogether if they would not alter management.[13]

The European Society of Gastrointestinal Endoscopy has endorsed the use of optical diagnosis in place of histopathology for diminutive colorectal polyps under strictly controlled conditions,[14] and has subsequently published a curriculum to develop and maintain the relevant skills.[15] Although a resect-and-discard strategy is referenced in a British guideline[16] and the findings of a meta-analysis confirm that minimum performance thresholds for imaging technologies have been met to implement this strategy,[17] this has not yet been widely implemented. Medicolegal concerns, lack of both awareness and financial incentives, and patient acceptability are some of the current hurdles.[18] Substitutes for histopathologic analysis will likely expand further with both the evolving indications for optical diagnosis and the growing use of artificial intelligence in the categorization of mucosal lesions.

Single-Use Consumables

Single-use consumables have become ubiquitous in modern health care over recent decades, likely because of a combination of infection concerns, profitability, efficiency, and reprocessing logistics. Endoscopic procedures also consume ancillary single-use plastics: intravenous cannulas, dressings, mouthguards, oxygen and suction tubing, endoscope buttons, bung valves, plastic caps, biopsy forceps, snares, diathermy pads and adapters, histology pots, and polyp traps. Only a fraction of these items are currently recyclable, and the majority are incinerated or enter a landfill.[19]

The volume of single-use personal protective equipment has increased greatly during the COVID-19 pandemic, with significant environmental impact implications.[20] Given the unclear duration that such recommendations may remain in place or, indeed, recur, departments should explore the options for reusable alternatives. Thermal technologies that compress used polypropylene products, such as personal protective equipment and other single-use plastics, into rectangular blocks that can be sold and converted into pellets for new plastic products reduce the volume of waste required to be transported offsite.[21] Trackable inventory systems can help minimize waste from expired supplies.

Single-Use Duodenoscopes

The reprocessing of endoscopes has received increased attention in recent years because of concerns over duodenoscope-related patient-to-patient transmission of infection. Duodenoscopes represent a significant reprocessing challenge for numerous reasons, and a recent meta-analysis of more than 13,000 samples reported an approximately 15% contamination rate of reprocessed patient-ready duodenoscopes.[22] Reported contamination rates have ranged from 0.3% to 60%, and the true magnitude of infection transmission is difficult to establish. Ongoing debate surrounds the most effective method for the reprocessing and culturing of duodenoscopes and the extent to which contamination translates into clinically relevant infection.[23]

Single-use endoscopes have been developed as a proposed solution to these issues. Notwithstanding the need to demonstrate economic, technical, and safety equivalence, there is concern over the environmental impact that a move to a single-use model may incur.

The reprocessing of reusable endoscopes is a resource-heavy process involving large volumes of water (approximately 30 gallons per cycle),[24] disinfectants, detergents, and electricity (24.67 kWh per day).[5] Even factoring in this resource requirement, preliminary life cycle assessment suggests that using single-use endoscopes, with an assumed infection rate of 0.02%, would produce 20 times the CO_2 emissions of reusable duodenoscopes.[25] Production of the duodenoscope accounted for 96% of the energy consumption and greenhouse gas emissions. However, these findings contrast with the findings of life cycle assessments of single-use bronchoscopes[26] and ureteroscopes,[27] where single use was not associated with higher overall emissions. A recently published waste audit has, however, further quantified the implications of a single-use endoscope model, suggesting that this would be associated with an up to 40% increase in total net waste mass after accounting for the lack of waste from reprocessing.[19]

The role for single-use endoscopes is a matter of ongoing debate, and some outstanding questions need to be considered: To what extent can single-use endoscopes be effectively recycled? What level of infection risk should be deemed acceptable? What are the environmental implications if the single-use model were extended to include gastroscopes and colonoscopes? The balance of environmental factors is complex, and further research, including full life cycle analysis, is required in this area.

Conclusion

There is no doubt that endoscopy contributes to the environmental impact of modern health care. Professional societies and governments have committed to mitigating this impact and have set sustainability as a core strategic objective for both policy and research.

Immediate, uncontroversial, and cost-neutral adjustments that we can make to our practice to mitigate this impact include quality triage, streamlining waste management, and rationalizing histopathology requests (Figure 1). Much of our current understanding of endoscopy's environmental impact is not drawn from empirical data but presupposed or reasonably inferred from that collected in other contexts. Although this can be useful, we need to be aware that supply chains are complex and that scope 3 emissions are opaque. Crude assumptions as to the comparative environmental impact of one action over another can generate well-intentioned interventions with unintended consequences: an increase in efficiency in a system can potentially result in rebound increased consumption of a resource (the Jevons paradox).

The use of life cycle assessment methodology will help build a more granular and comprehensive understanding of our ecological footprint. To better predict the benefit of intervention, we need to know where emissions are embedded and where they are distributed across a process. We also need to better understand where stakeholders' priorities lie with regard to the aim of improving the triple bottom line of health care's economic, social, and environmental impacts.

Understanding the complexities of these issues and understanding how to influence positive environmental change can be challenging for individual clinicians and their service managers. This issue of *Gastroenterology* includes 2 related commentaries, providing an overview of health care sustainability[28] and the impact of climate change on liver disease.[29] Professional medical societies can help with both knowledge and practical guidance; the World Gastroenterology Organisation has suggested a way forward for gastroenterology and hepatology societies[30]; the British Society of Gastroenterology has produced a "Climate Change & Sustainability" strategy[31]; and the American Gastroenterological Association, American Society for Gastrointestinal Endoscopy, American College of Gastroenterology, and American Association for the Study of Liver Diseases are planning a joint strategic approach to this issue. A momentum is gathering, and around the world, other professional societies are starting to engage with this issue.

Our endoscopic ancestors met the challenge of their time: the need to bend light's straight lines around a flexible tube. Perhaps the challenge for our generation of endoscopists is not so much technical as it is structural: to bend the shape of endoscopy's wasteful linear economy into something altogether more restorative and circular.

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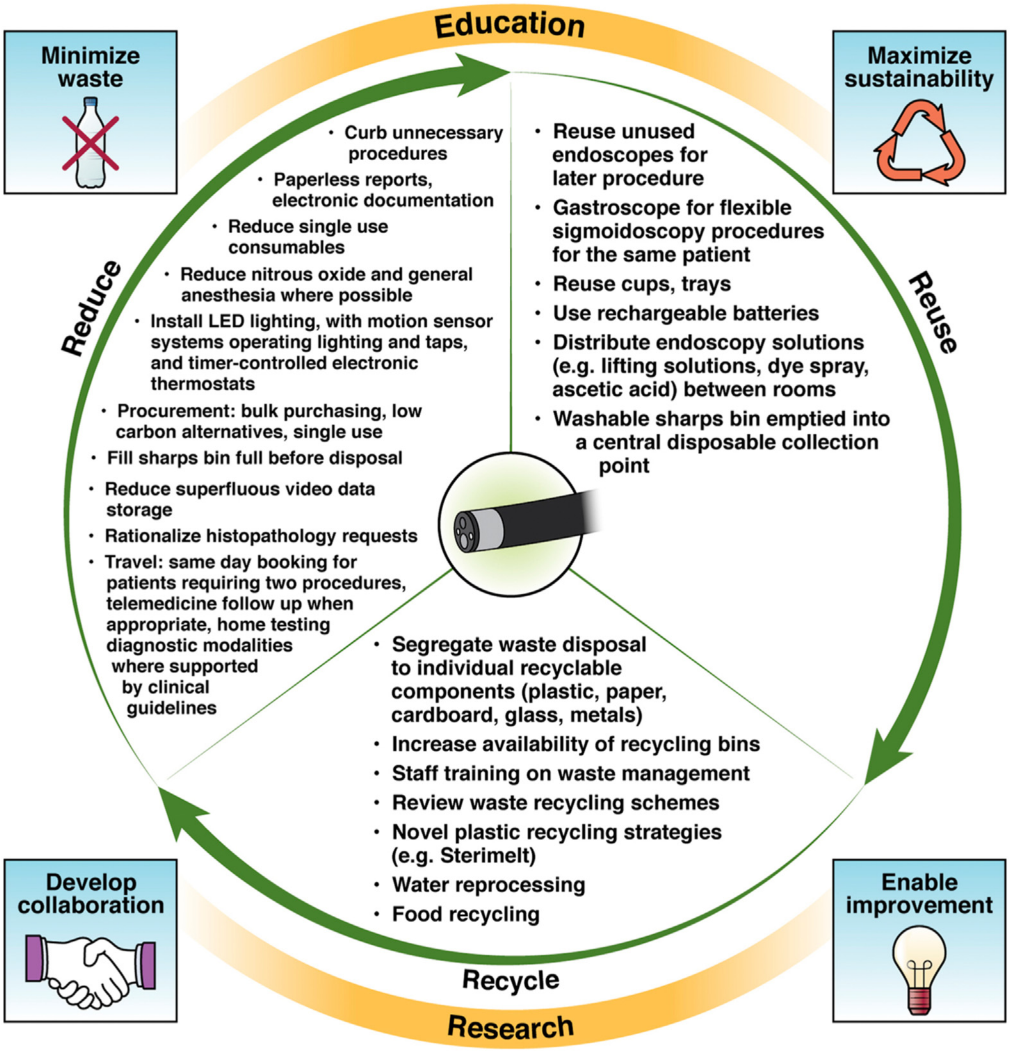

Figure 1. Sustainability in endoscopy is guided by the 3 *R*s approach of reduce, reuse, recycle. Education and research underpin this approach to support impactful behavior change and improvements. Collaborations among specialties, including microbiology and infection prevention and control teams, as well as industry will also be central to building a sustainable future for our specialty.

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