Guideline for the Implementation of Green Endoscopy in Paediatric Practice

Author: Dr Shishu Sharma, Endoscopy Chair BSPGHAN

On behalf of Endoscopy Working group

Dr Dharam Basude, Dr Lucy Myers, Dr Iain Chalmers, Dr Dan Crespie, Dr David Cairney, Dr Joseph Machta, Dr Sabarinathan Loganathan, Dr Morumbo Mtegha, Dr Naomi Scable, Dr Vinod Kolimarala, Dr Chris Bakewell

Executive Summary

Paediatric gastrointestinal endoscopy is an essential diagnostic and therapeutic service but is associated with a measurable environmental footprint. This arises from the frequent use of general anaesthesia, energy-intensive endoscopy units, water-intensive endoscope reprocessing, single-use consumables, and downstream pathology processing. As healthcare systems commit to rapid decarbonisation, paediatric endoscopy services have an opportunity—and responsibility—to reduce avoidable environmental impact while maintaining high standards of clinical care.

This guideline provides practical, evidence-informed recommendations for implementing green endoscopy within paediatric services supported by BSPGHAN and CAPGHAN. It focuses on areas where paediatric clinicians and services can exert the greatest influence: appropriate patient selection, high-quality biopsy practice, efficient use of resources, and strong local leadership.

Key principles include:

- Appropriateness of endoscopy: Careful patient selection is the most effective way to reduce emissions. Evidence from paediatric centres demonstrates that diagnostic yield and management impact vary by indication, reinforcing the importance of structured referral vetting and the use of non-invasive investigations where appropriate.
- Getting it right first time: When endoscopy is undertaken, it should be performed to a standard that minimises the risk of repeat procedures. This includes complete examinations and taking biopsies that are appropriate to the clinical question, even when macroscopic appearances are normal and patient allocation based on endoscopy skill sets.
- Leadership and accountability: Each paediatric endoscopy service is encouraged to nominate a Green Endoscopy Champion to coordinate sustainability work, link with multidisciplinary teams, and embed environmental considerations into routine governance and quality improvement processes.

- Anaesthesia, reprocessing and pathology: Because paediatric endoscopy commonly involves general anaesthesia, collaboration with anaesthetic teams is essential to reduce avoidable emissions where clinically safe. Significant water use in endoscope decontamination and the environmental impact of biopsy processing and formalin use highlight the importance of working with decontamination and pathology services to identify efficiencies and innovations.
- Measurement and continuous improvement: Regular audit of diagnostic yield, biopsy practice, repeat procedures, and resource use allows services to track progress and identify high-impact opportunities for improvement.
- Careful consideration of digitalisation of slides can reduce the impact on storage costs, transport and retrieval.

By integrating sustainability into everyday clinical decision-making rather than treating it as a separate agenda, paediatric endoscopy services can contribute meaningfully to healthcare decarbonisation. The recommendations in this guideline are intended to support centres in delivering environmentally responsible care that remains safe, effective, and centred on the needs of children and young people.

1. Aim and scope

This guideline provides practical recommendations to support the delivery of environmentally sustainable paediatric gastrointestinal (GI) endoscopy, without compromising diagnostic accuracy, patient safety, or training standards. It applies to upper GI endoscopy, ileocolonoscopy and flexible sigmoidoscopy performed in children and young people, most of which are undertaken under general anaesthesia (GA) or deep sedation.[1]

2. Background and rationale

2.1 Healthcare and climate responsibility

Healthcare systems contribute materially to greenhouse gas emissions. In England, the National Health Service (NHS) has been estimated to account for approximately 4–5% of the national carbon footprint.[2] In response, the NHS has committed to achieving net zero emissions for activities it directly controls by 2040, and for emissions it can influence by 2045.[3] Paediatric services, including endoscopy, form part of this responsibility.

2.2 Environmental footprint of paediatric endoscopy

Paediatric GI endoscopy involves multiple emission sources, including anaesthesia, energy-intensive endoscopy units, water-intensive decontamination processes, single-use consumables, and pathology processing.

Carbon emissions

Paediatric-specific life cycle data are limited; however, available evidence provides useful estimates:

- A paediatric analysis of coeliac disease diagnostic pathways estimated ~5.4 kg CO_2 per upper GI endoscopy and ~22 kg CO_2 per general anaesthetic, based on published emissions factors.[1]
- Adult whole-pathway analyses provide context, estimating ~18–49 kg CO_2e per endoscopic procedure, depending on assumptions, setting, and inclusion of building energy and travel.4,6

Although extrapolation from adult data must be cautious, the frequent requirement for GA in paediatric endoscopy means anaesthetic-related emissions are particularly relevant.

Water consumption

Flexible endoscope decontamination requires substantial water input. Published evaluations report that a single complete reprocessing cycle may use approximately 55–113 litres of water, with manual cleaning alone accounting for around 15–20 litres, depending on local protocols and equipment.[7]

Biopsies, pathology and formalin

Histological analysis is central to paediatric GI diagnosis but contributes to environmental impact:

- Processing of gastrointestinal biopsy specimens in surgical pathology laboratories has been estimated to generate ~0.29–0.79 kg CO_2e per biopsy, depending on processing pathways.[8]
- Tissue fixation typically uses formalin, an aqueous solution containing approximately 37% formaldehyde.[9] Formaldehyde is associated with recognised environmental hazards, including aquatic toxicity, as described in regulatory assessments.[10]
- Interventions such as formalin recycling systems in pathology laboratories have demonstrated substantial reductions in greenhouse gas emissions and toxicity indicators, with one study reporting a reduction of over 2400 kg CO_2e following implementation.[11]

3. Leadership and governance

3.1 Principles

Each paediatric endoscopy centre should designate a named Green Endoscopy Champion. This is a recommended service model to support implementation rather than a mandated role. The champion may be a clinician, nurse endoscopist, operational lead, or manager, depending on local structures.

3.2 Responsibilities of the Champion

Key responsibilities should include:

1. Coordinating local sustainability initiatives within paediatric endoscopy services.
2. Acting as a liaison between endoscopy, anaesthesia, decontamination, pathology, estates, procurement and sustainability teams.
3. Leading audit and quality improvement (QI) projects related to environmental impact.
4. Supporting education and engagement of staff around green endoscopy principles.
5. Reporting progress through existing clinical governance frameworks.

4. Appropriateness of endoscopy: patient selection

4.1 Principle

Avoiding endoscopic procedures that are unlikely to alter diagnosis or management is one of the most effective ways to reduce environmental impact, provided that patient outcomes are not compromised.

4.2 Evidence in paediatric practice

A tertiary-centre paediatric study reported diagnostic yields of:

- 18.9% for upper GI endoscopy alone
- 32.6% for ileocolonoscopy alone
- 39.2% when upper and lower GI endoscopy were combined

Endoscopic and histological findings led to a change in clinical management in 45% of cases, and terminal ileal intubation was achieved in 98% of procedures.[12] These data highlight both the value of appropriate endoscopy and the need to avoid low-yield investigations.

4.3 Recommended actions

Paediatric endoscopy units should:

1. Implement structured referral vetting, ideally consultant-led, for all elective procedures.
2. Use indication-based criteria aligned with paediatric GI guidance to identify children most likely to benefit from endoscopy.
3. Promote non-invasive testing pathways (e.g. faecal calprotectin, coeliac serology) where appropriate before proceeding to endoscopy.
4. Plan combined upper and lower GI endoscopy in a single session when clinically indicated, to minimise repeat admissions and repeat anaesthesia exposure.
5. Robust pre and peri-operative pathways for thorough assessment and communication with multidisciplinary teams avoiding delays, cancellations, and effective bowel preparation.
6. Allocate patient to appropriate lists based on advanced skill sets where possible.

5. Biopsy practice: balancing diagnostic quality and sustainability

5.1 Importance of appropriate biopsies

In paediatric gastroenterology, normal macroscopic appearances do not reliably exclude histological disease. Inadequate sampling risks missed diagnoses and may necessitate repeat endoscopy, increasing both clinical risk and environmental burden.[13]

5.2 Green biopsy principle

The objective is to take the minimum number of biopsies required to answer the clinical question to an accepted diagnostic standard, avoiding both over-sampling and under-sampling.

5.3 Practical recommendations

Paediatric endoscopy units should:

1. Use indication-specific biopsy protocols embedded in reporting systems.
2. Incorporate a planned biopsy checklist as part of the endoscopy safety pause.
3. Avoid “routine” biopsies without a clear diagnostic purpose.
4. Rationalise the number of specimen pots where clinically appropriate, in collaboration with pathology services.
5. Review biopsy numbers per procedure as part of routine audit.

6. Anaesthesia and procedure room considerations

Because most paediatric endoscopies are performed under GA, anaesthetic practice is a key determinant of emissions.

- Inhaled anaesthetic agents vary substantially in global warming potential, with some agents having markedly higher climate impact than others. [14,15]
- Where clinically appropriate, anaesthetic teams should consider lower-emission techniques and minimise avoidable fresh gas flows.
- Close collaboration between paediatric gastroenterology and anaesthesia teams is essential to ensure patient safety remains paramount.

Procedure room and equipment:

- Green Energy efficient equipments (eg LED) and effective use of standby power modes.
- Digital documentation and correspondence

7. Endoscope reprocessing and water use

Endoscopy units should work with decontamination services to:

1. Understand and, where possible, measure local water use associated with reprocessing.
2. Ensure that reprocessing protocols are efficient while remaining fully compliant with infection prevention standards.
3. Review manual cleaning steps to avoid unnecessary water use where validated alternatives exist.[7]
4. Effective use of storage units.

8. Waste and consumables

Practical measures to reduce waste include:

- Rationalising procedure packs to remove items that are rarely used.
- Preferring reusable equipment where safe and supported by evidence and policy.
- Improving waste segregation to reduce inappropriate disposal of recyclable or domestic waste as clinical waste.
- Rational use of consumables eg using the same connectable tubings for the whole list, Biodegradable options etc.

9. Audit and quality improvement

Suggested metrics include:

- Diagnostic yield by indication.
- Rate of combined versus single procedures.
- Number of biopsies per case by indication.
- Repeat endoscopy rates due to insufficient diagnostic information.
- Proxy measures of water use and waste segregation compliance.

These data should be reviewed regularly and used to inform QI cycles.

10. Digitalisation

10.1 Principles

There is good evidence that digitising histopathology slides (whole slide imaging / digital pathology) can reduce or eliminate physical slide transport and can reduce the operational burden of physical storage and retrieval. The evidence is stronger for workflow and cost impacts (couriers, packing, retrieval time, lost/broken slides), with less direct published quantification of the carbon impact of transport specifically (though the transport reduction is logically clear and often explicitly described).

Digital pathology (whole slide imaging) can reduce or remove the need for physical slide transport for MDT discussion, network reporting and second opinions, and can reduce operational burdens associated with physical slide retrieval and handling. However, digitisation shifts part of the environmental and cost burden toward data storage and IT infrastructure; net sustainability benefit is therefore greatest when services measure courier reduction and manage storage/compute efficiently.

10.2 Transport (couriers, slide sending for MDT, second opinions, network reporting)

- Reviews of digital pathology implementation note that digital workflows can reduce time and costs linked to preparing and transporting physical slides, because cases can be shared electronically instead of dispatched as glass.[16]
- An implementation/lessons-learned review describes that using digital slide images removes the need to transport and handle physical slides afterwards, particularly for sharing and review.[17]
- The UK "case for clinical adoption of digital pathology" report explicitly lists savings from eliminating packing, postage, and transport costs for inter-site slide/tissue transfer and external review.[18]
- RCPath's report on digital pathology emphasises that digital slides are portable and instantly transmissible, addressing constraints of physical slide movement.[19]

10.3 Storage and retrieval

- Evidence briefs and professional reports highlight the operational issues of managing physical slide archives (retrieval from storage, transport, risk of damage/misplacement) and describe digitisation as a way to overcome limitations of glass collections, including sharing.[20]
- The UK adoption report describes reduced time spent retrieving slides from archives, "chasing missing slides," and re-cutting/re-staining when slides are damaged, which are real operational costs in glass-based systems.[18]
- RCPath similarly frames digital pathology as addressing the physical limitations of glass slide storage and movement.[19]

10.4 Costs (transport costs, labour, and indirect operational savings)

- The UK adoption case report is one of the clearest sources that explicitly claims packing/postage/transport costs are eliminated and that staff time spent on assembling/dispatching/retrieving/chasing slides is reduced.[18]
- Value/implementation reports (e.g., large centre experiences) describe formal cost analyses including operational impacts once scanning is embedded.[21]

10.5 Sustainability / emissions angle (what's known and what needs caution)

- Digital pathology can plausibly reduce emissions via fewer courier journeys and reduced repeat work from lost/damaged slides; this is frequently discussed in "green" narratives, but robust LCAs for digital vs glass workflows are still evolving.
- At the same time, digitisation introduces data centre/storage energy demand and can add compute load (especially if AI is used). The digital health sustainability literature stresses that digital interventions need life-cycle evaluation, because benefits from reduced travel/transport can be partly offset by IT energy/storage.[22]
- There is specific modelling work on greenhouse gas emissions from compute in digital pathology (deep learning), underscoring that compute is not free environmentally and should be managed intelligently (e.g., efficient hardware, scheduling, cloud choices).[23]

10.6 Recommendations

1. For regional centres digitalisation is one of the most direct levers to cut courier movements and reduce delay and risk associated with sending glass slides.[18, 20]

2. The digital pathology often shifts the “storage problem” from physical space + manual retrieval labour to data storage + IT governance, hence the evidence to spport this move comes with mixed evidence.

3. The savings associated with digitalisation should be weighed in and compared with material costs e.g. scanner as well as storage costs.[18,21]

3. The best-supported sustainability claim is reduced physical transport and handling, but a rigorous “net carbon” claim needs local measurement of a courier reduction and storage/IT energy footprint.[22, 23]

Conclusion

Green endoscopy in paediatric practice is achievable through careful patient selection, appropriate biopsy practice, efficient use of resources, and strong local leadership. By embedding sustainability into routine clinical decision-making, paediatric endoscopy services can contribute to healthcare decarbonisation while continuing to deliver high-quality, child-centred care.

References

1. Brusco M, Benning L, Snyder J, et al. The environmental impact of paediatric coeliac disease diagnosis and follow-up. JPGN Reports. 2025;4(1):eXXX.
2. NHS England. Progress report: delivering a greener NHS – five years on. London: NHS England; 2025.
3. NHS England. Delivering a ‘Net Zero’ National Health Service. London: NHS England; 2020.
4. Lacroute J, Lelong B, Benamouzig R, et al. Carbon footprint of ambulatory gastrointestinal endoscopy. Endoscopy. 2023;55(7):678–686.
5. Leddin D, Omary MB, Adler DG, et al. Carbon footprint of routine endoscopic procedures: a comprehensive assessment from three US endoscopy units. Endoscopy. 2025;57(Suppl 1):S1–S8.
6. García-Castellanos M, González-Alonso J, Rodríguez-de-Santiago E, et al. Carbon footprint assessment and sensitivity analysis of diagnostic colonoscopy. Endoscopy. 2025;57(3):247–255.
7. Hicks J, Walsh K, Wilkinson J, et al. Streamlining endoscopy cleaning: the impact of detergent choice on time and water use. J Hosp Infect. 2025;139:1–7.
8. Gordon IO, Selby K, Reddy N, et al. Life cycle greenhouse gas emissions of gastrointestinal biopsies in a surgical pathology laboratory. Am J Clin Pathol. 2021;156(3):433–442.
9. UK Health Security Agency. Formaldehyde: general information. London: UKHSA; 2023.

10. United States Environmental Protection Agency. Formaldehyde: hazard summary and environmental fate. Washington, DC: US EPA; 2022.
11. Rullier A, Marchal F, Vignaud JM, et al. Recycled formalin: a new tool to mitigate the environmental impact of surgical pathology in routine practice. Pathology. 2025;57(2):213–219.
12. Thomson M, Sharma S. Diagnostic yield of upper and lower gastrointestinal endoscopies in children in a tertiary centre. J Pediatr Gastroenterol Nutr. 2017;64(6):903–909.
13. BSPGHAN. Reducing the carbon footprint of paediatric upper gastrointestinal endoscopy. Abstract OC71. In: BSPGHAN Annual Meeting Abstract Booklet; 2022.
14. American Society of Anesthesiologists. Environmental impact of inhaled anesthetics. Schaumburg, IL: ASA; 2023.
15. Wyssusek KH, Keys MT, van Zundert AAJ. Operating room greening initiatives – the anaesthesiologist's role. Anaesthesia. 2019;74(Suppl 1):S44–S52.
16. Hanna MG, Reidy J, et al. Digital pathology systems enabling quality patient care. J Pathol Inform / review (PMC). 2023.
17. Schwen LO, et al. Digitization of Pathology Labs: A Review of Lessons Learned. Lab Investigation. 2023.
18. Williams BJ, et al. The case for clinical adoption of digital pathology (UK report). 2017.
19. Royal College of Pathologists. Digital pathology – future proofing cancer diagnostic services (PDF).
20. NHS Evidence/ewin. Histopathology Evidence Brief (July 2025) – storage/transport/retrieval limitations and digitisation benefits.
21. Hanna MG, et al. Implementation of Digital Pathology Offers Clinical and Operational Value (MSK value/operational analysis PDF). 2019.
22. Lokmic-Tomkins Z, et al. Assessing the carbon footprint of digital health interventions: a scoping review. J Am Med Inform Assoc. 2022.
23. Sadr AV, et al. Operational greenhouse-gas emissions of deep learning in digital pathology: a modelling study. Lancet Digital Health. 2024.